16

Bench Work and Fitting

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16·1 Introduction

The bench work and fitting plays an important role in every engineering workshop to complete and finish the job to the desired accuracy. Though today in industries most of the work is done on automatic machines and finished to a fairly good degree of accuracy, still they require some operations to be done by hand to finish them to the desired accuracy. The work carried out by hand at the bench is called *bench work*, whereas *fitting* is the assembling of parts together by filing, chipping, sawing, scraping, tapping etc., necessary after the machine operation. This may or may not be carried out at the bench.

16·2 Fitting Tools

The tools used in fitting practice may be classified into the following groups :

1. Holding tools,
2. Striking tools,
3. Cutting tools,
4. Scraping tools,
5. Drilling tools, and
6. Measuring, marking and testing tools.

We shall now discuss these tools, in detail, in the following pages.

16·3 Holding Tools (Vices)

The holding tools or vices are required to hold the work firmly. Following are the various types of vices for different purposes.

1. *Bench vice.* It is used for holding the work and is firmly fixed to the bench with bolts and nuts. It consists of an iron or steel cast body, square threaded screw, nut, handle (made of mild steel), two jaws and jaw plates (made of cast steel) as shown in Fig. 16.1. One of the two jaws is stationary, while the other jaw is movable which can be brought close on the work by rotating the square threaded screw in the nut. The jaws plates are knurled on one side and fixed in the jaws with the help of screws and can be replaced when worn out. The knurling is done to help in gripping the work. For holding soft material or finished work, soft plate liners or coverings made of lead, fibre, copper, brass or tin plate are fitted over the jaws for giving protective grip in order to prevent the surface of the finished work from damaging.

The height of the bench should be such that the top of the vice jaws is at about the same height as the operator's elbow. The size of the vice is given by the width of the jaws and the maximum opening between the jaws.

Some vices are provided with a swivelling base which enables them to be rotated and fixed in angle so that the work can be located in any desired position.

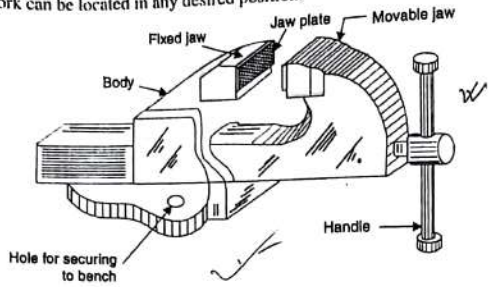


Fig. 16.1. Bench vice.

2. *Hand vice.* It consists of two jaws and hands which are hinged together, on a pivot, on the opposite ends as shown in Fig. 16.2. The work is held in between the serrated faces of the jaws with a screw and a wing nut. A flat spring, fixed between the two hand jaws, helps open them out by its pressure. The vice is held in one hand and the required operation is performed by the other hand. It is used for gripping small objects such as screws, rivets, small drills, keys of locks and other similar objects which are too small to be conveniently held in bench vice.

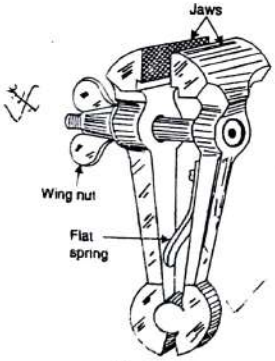


Fig. 16.2. Hand vice.

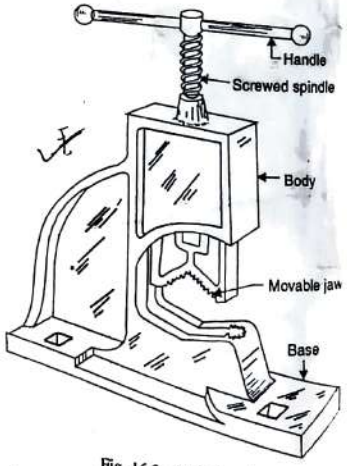


Fig. 16.3. Pipe vice

3. *Pipe vice.* It is used for holding pipes, shafts or round jobs. It works on the same principle as the bench vice. It consists of two jaws, one of which is fixed and the other is movable, as shown in Fig. 16.3. The shape of the jaws is like a V and it grips the work at four points or its surface.

4. *Leg vice.* It is generally used in a smithy shop, but it is also suitable for heavy hammering, chipping and cutting in fitting shop. The vice is secured to the top of the bench by an iron strap which is fastened to a plate bolted to the bench top. It differs from the bench vice in that the movable jaw is

pivoted about a point near to the middle of the leg of the vice. This prevents the faces of the two jaws from being parallel to each other in every position except one position.

5. *Pin vice.* This is a holding device for small diameter work, such as wires and pins. It consists of a fine self centering chuck on a handle which may be of wood or metal, as shown in Fig. 16.4. The work is gripped between the jaws of the chuck by rotating the handle.

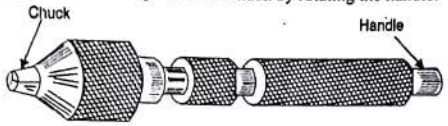


Fig. 16.4. Pin vice.

6. *Tool maker's vice.* It is particularly used for holding small work for filing or drilling. It is made of mild steel. It consists of a body with a solid jaw, a movable jaw, a screw and a handle for the control of movement of movable jaw, as shown in Fig. 16.5.

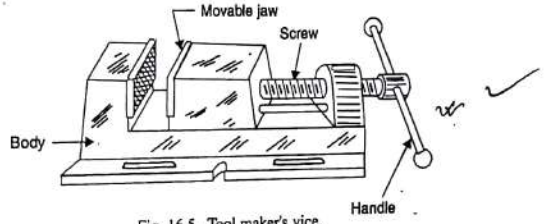


Fig. 16.5. Tool maker's vice.

16·4 Care of Vice

The Following points should be kept in mind while using a vice :

1. The vice should be kept clean and free from dust and metal chips by using a brush.
2. The threads and the nut should be occasionally oiled.
3. The vice should never be used as an anvil.
4. The serrated jaws should be covered with soft metal clamps when finished work is held.
5. For holding tubes, temporary wooden 'V' blocks should be used.

16·5 Striking Tools (Hammers)

The striking tools or hammers are used to strike the job or tool. A hammer consists of a head, striking face, peen and a shaft or handle as shown in Fig. 16.6. The hammer heads are made from a plain steel of about 0.6% carbon and are shaped by stamping or forging. The two ends (*i.e.*, face and peen) must be hardened and tempered and the centre of the head, with the eye, is left soft. The eye has an oval through recess, enlarged at one end, to accommodate the end of the shaft which is secured by inserting a hard wood or metal wedge into it. The shaft or handle is made of well seasoned, straight grained wood and it should be so shaped and sized that when gripped, it gives an easy feel to the hand. The size of the hammer is indicated by its weight. The various types of hammers in common use are as follows :

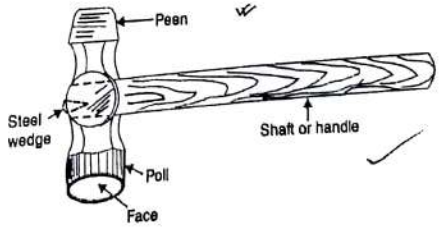


Fig. 16.6. Hammer.

1. *Ball-peen hammer.* The ball-peen hammer, as shown in Fig. 16.7(*a*), has the peen of the shape of a ball. It is the most common type of the hammers and is mostly used for riveting (*i.e.*, for forming a snap head on the tail of a rivet) and chipping. According to Indian standards (IS : 841-1957), the size of ball peen hammer varies from 0.11 kg to 0.91 kg.

(*a*) Ball peen hammer. (*b*) Cross peen hammer. (*c*) Straight peen hammer.

(*d*) Double-headed hammer. (*e*) Lead hammer. (*f*) Raw-hide headed hammer.

Fig. 16.7. Types of hammers.

2. *Cross-peen hammer.* The cross-peen hammer, as shown in Fig. 16.7(*b*), is similar to ball-peen hammer except that its peen is like a wedge which is perpendicular to the handle. It is used for bending, stretching, hammering into shoulders, inside curves etc. According to Indian standards (IS : 841 - 1957), the size of cross-peen hammer varies from 0.22 kg to 0.91 kg.

3. *Straight-peen hammer.* The straight-peen hammer, as shown in Fig. 16.7(*c*), has its peen straight or parallel to the handle. The width of peen is usually equal to the diameter of the face. It is used for stretching or peening the metal by hammering or fullering. According to Indian standards (IS : 841 - 1957), the size of straight-peen hammer varies from 0.11 kg to 0.91 kg.

4. *Double-faced hammer.* The double-faced hammer, as shown in Fig. 16.7(*d*), consists of a head which has two identical faces at both ends. It is used for striking cup tools for riveting.

5. *Soft hammer.* The soft hammers are used for striking finished surface which would be damaged by the hardened face of a hammer. The two types of soft hammers are shown in Fig 16.7(*e*) and (*f*). The *lead hammer,* as shown in Fig. 16.7(*e*), has a lead head cast on to a length of steel tube. The *raw hide hammer*, as shown in Fig. 16.7(*f*), has a cast iron head into which raw-hide plugs are inserted. These plugs can be replaced when they are worn out. The soft hammers may also be made of wood, hard rubber, copper and brass.

16·6 Cutting Tools

The chief cutting tools used in fitting are cold chisels, hacksaws and files. These are discussed, in detail, in the following pages.

16·7 Cold Chisels

The cold chisel, as shown in Fig. 16.8, is an important cutting tool used by

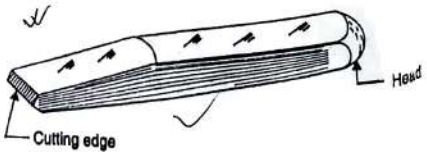


Fig. 16.8. Cold chisel.

the fitter. It is distinguished from other chisels by the fact that it has no wooden handle. These are used to cut the cold metal and are made by forging from cast tool steel of octagonal cross-section. The length of the chisels is about 15 cm to 20 cm and the tapered part is from 5 cm to 8 cm long. The chisels are being made from 10 mm to 25 mm thick material.

The cutting edge is ground to an angle suited to the material being worked upon. After forging to shape and roughly grinding, the cutting edge should be hardened and tempered. The various angles formed on the chisel are cutting angle, clearance angle and rake angle as shown in Fig. 16.9. The most commonly used cutting angle is 60°, but this varies according to the type of material cut. The following table shows the least cutting angles for different materials.

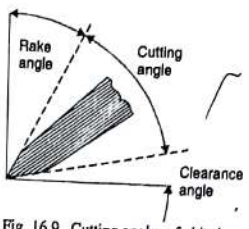


Fig. 16.9. Cutting angles of chisel.

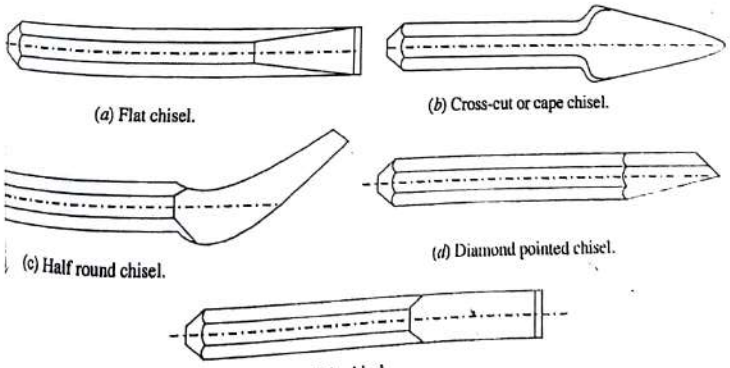
Table 16.1. Cutting angles for different materials.

Material	*Cutting angles*
Aluminium	30°
Copper	45°
Brass	50°
Wrought iron and mild steel	55° to 60°
Cast iron	60° to 65°
Cast steel	70°

16·8 Types of Chisels

The various type of chisels commonly used for fitting are as follows :

1. *Flat chisel.* A flat chisel, as shown in Fig. 16.10(*a*), is the most common of all the chisels. has a wide cutting edge about 16 mm to 32 mm and is slightly rounded to prevent the corners from igging into the metal. The length of the chisel varies from 100 mm to 400 mm. It is used for ipping flat surfaces, cutting off sheet metal, cutting bars and rivets.



(*a*) Flat chisel. (*b*) Cross-cut or cape chisel.

(*c*) Half round chisel. (*d*) Diamond pointed chisel.

(*e*) Side chisel.

Fig. 16.10. Type of chisels.

2. *Cross-cut chisel or cape chisel.* A cross-cut or cape chisel, as shown in Fig. 16.10(*b*), has a cutting edge about 4 mm to 12 mm wide. From the edge, the metal thickness tapers off slightly. This is to permit the chisel to clear when a groove is being cut. It is widely used for cutting grooves in large surfaces before using the flat chisel. It is also used for cutting keyways in wheels and shafts.

3. *Half-round chisel.* A half-round chisel, as shown in Fig. 16.10(*c*) has a semi-circular cutting edge. The width of the cutting edge varies from 2 mm to 16 mm and length varies from 150 mm to 250 mm. It is used for cutting round or semi-circular oil grooves in bearings, bosses and pulleys.

4. *Diamond pointed chisel.* A diamond pointed chisel, as shown in Fig. 16.10(*d*) has a cutting edge shaped like a diamond. The width of the cutting edge varies from 6 mm to 16 mm and length varies from 100 mm to 400 mm. It is used to cut V-grooves and to chip square corners.

5. *Side chisel.* The side chisel, as shown in Fig. 16.10(*e*), has the cutting edge bevelled on one side only. It is particularly used for chipping and removing surplus metal in cotter ways and slots which are to be cut by hand after drilling.

16-9 Chipping

The operation used for cutting or removing thick layers of metal by means of cold chisels, is known as *chipping*.

The chipping operation is carried out as follows :

1. The work is firmly held in a vice.
2. The chisel is firmly gripped in the left hand leaving some distance above the thumb of the hand as shown in Fig. 16.11.
3. The hammer is grasped near the end of the hammer in the right hand. In operation, it should be brought upto the shoulder to ensure more power in the blows.

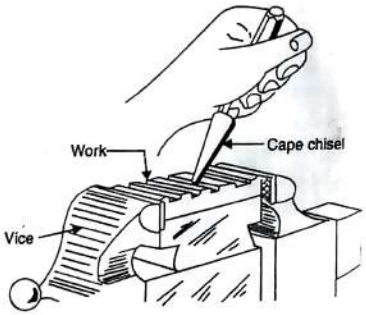


Fig. 16.11. Method of chipping.

The following points should be kept in mind while chipping the surface.

(*a*) The same cutting angle of the chisel must be maintained during the chipping operation.

(*b*) If the surface to be chipped is very large, it is advisable to cut grooves along the whole surface by means of a cross-cut or cape chisel and then chip off the remaining metal.

(*c*) When removing large amount of metal, it is necessary to lubricate the cutting edge frequently in order to have longer life of the chisel and to make chipping easier and smoother.

(*d*) The operator who performs the chipping operation, should always keep his eyes on the cutting edge of the chisel and not at the head.

16-10 Files

A file is a hardened piece of high grade steel with slanting rows of teeth. It is used to cut, smooth or fit metal parts. It cuts all metals except hardened steel and it cuts only on the forward stroke. It consists of a *blade* or *body* with a *tang* for fixing into the *wooden handle*, as shown in Fig. 16.12. The teeth are cut on the blade which are hardened and tempered. The tang is tempered to make it soft and tough. The various parts of the blade are shown in Fig. 16.12. The metal ring on the file handle is called *ferrule*, in order to prevent splitting of the handle. The files are classified according

to the size, cut of teeth, grade and shape or cross-section of the file as discussed below :

(*a*) *Size of file.* The *size* of the file is indicated by its length. It is the distance from the *point* to the *heel* without tang. The length of the file, in general use, is 200 mm to 450 mm and 100 mm to 200 mm for finer work.

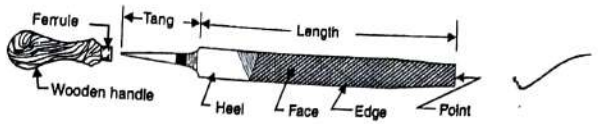
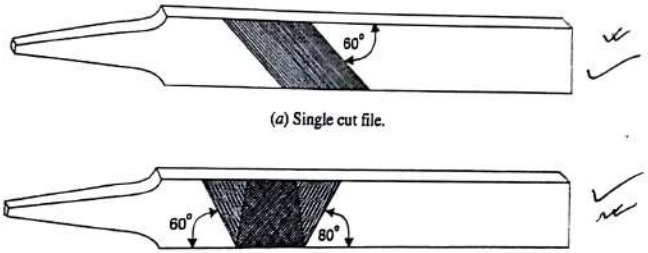


Fig. 16.12. Parts of a file.

(*b*) *Cut of teeth.* The files, according to the *cut of teeth*, are divided into two groups, *i.e.*, *single cut* and *double cut*.

In *single cut files*, the teeth are cut parallel to each other running across the faces and at angle of 60° to the centre line of the file, as shown in Fig. 16.13(*a*), These files are frequently termed as *flats* and are particularly used for very hard metals.



(*a*) Single cut file.

(*b*) Double cut file.

Fig. 16.13. Single cut and double cut file.

In *double cut files*, there are two sets of teeth. The first set of teeth are similar to those of single cut files (*i.e.*, at 60° to the centre line of the file) while the second set of teeth are cut diagonally across the first set of teeth at an angle of about 80° to the centre line of the file as shown in Fig. 16.13(*b*). All the teeth have negative rake *i.e.*, sloping backwards by which they cut only on the forward stroke. It removes metal faster and is used for general work.

(*c*) *Grade of cut of file.* The single cut and double cut files, depending upon the pitch of the teeth (*i.e.*, spacing between the rows of teeth) may be classified as rough (R), bastard (B), second cut (SC), smooth (S), dead smooth (DS) and superfine or supersmooth (SS). The number of teeth per 10 mm length and their uses for each of these grades of files are given in the following table.

Table 16.2. Grades of files and their uses.

S.No.	Grade of file	Effective length of file in mm							Uses
		100	150	200	250	300	350	400	450	
		Number of cuts per 10 mm of length								
1.	Rough (R)	10	8	7.1	6.3	5.5	5.3	4.8	4.5	It is used for heavy reduction and filing casting after chipping.

S.No.	Grade of file	Effective length of file in mm								Uses
		100	150	200	250	300	350	400	450	
		Number of cuts per 10 mm of length								
2.	Bastard (B)	18	13	11	10	9	8	7	6	It is used for reducing bulky work.
3.	Second cut (SC)	21	17	16	15	14	13	12	11	It is used for general work.
4.	Smooth (S)	30	24	20	20	19	18	16	15	It is used for smoothening surfaces and filing delicate work.
5.	Dead Smooth (DS)	35	33	31	30	28	–	–	–	These are used by toolmakers and silver smiths for high accuracy and finish.
6.	Supersmooth (SS)	63	49	45	40	–	–	–	–	

In may be noted that coarseness or pitch of the file varies directly as the length of the file. Thus larger the length of the file, coarser will be the pitch and smaller the file, finer will be the pitch.

(*d*) *Shape of files.* The files, according to their shape or cross-section, are classified as discussed below :

1. *Flat file.* A flat file, as shown in Fig. 16.14(*a*), is parallel for about two-thirds of its length and then tapers in width and thickness. It has double cut on both faces and single cut on both edges. It is mostly used for general work and for filing flat surfaces.

2. *Hand file.* A hand file, as shown in Fig. 16.14(*b*), has its width parallel throughout, but its thickness tapers. The both faces are double cut and one edge single cut. The uncut edge is called the *safe edge* and prevents cutting into one face of a square corner while the other face is being filed. It is used for general surfacing work, more particularly for filing steps or shoulders to square work without touching and spoiling the adjacent surface, already made true.

3. *Square file.* A square file, as shown in Fig. 16.14(*c*), is parallel for two-thirds of its length and then tapers towards the tip. It is double cut on all sides and is used for filing square corners and slots.

4. *Pillar file.* A pillar file, as shown in Fig. 16.14(*d*), is similar to hand file, but is narrower and thicker than hand file. It has one or both uncut edges (*i.e.*, safe edges) and is used for narrow work such as keyways, slots and grooves.

5. *Triangular file.* A triangular file, as shown in Fig. 16.14(*e*), has width either parallel throughout or upto middle and then tapered towards the tip. Its cross-section is triangular (equilateral) and the three faces are double cut and edges single cut. It is used for filing square shoulders or corners and for sharpening wood working saws.

6. *Round file.* A round file, as shown in Fig. 16.14(*f*), has round cross-section. A file with width parallel throughout is called *parallel round* and the file with width parallel upto middle and then tapering towards the tip is called *rat file.* The round files are usually double cut on the Rough and Bastard qualities over 15 cm long while the Rough and Bastard under 15 cm, together with second cut and smooth, are single cut. The round files are used for opening out holes, producing round corners, round-ended slots etc.

7. *Half round file.* The section of a half round file, as shown in Fig. 16.14(*g*), is not a true half circle but is only about one-third of a circle. The width of the file is either parallel throughout or upto middle and then tapered towards the tip. The flat side of this file is always double cut and curved side has single cut. It is used for filing curved surfaces.

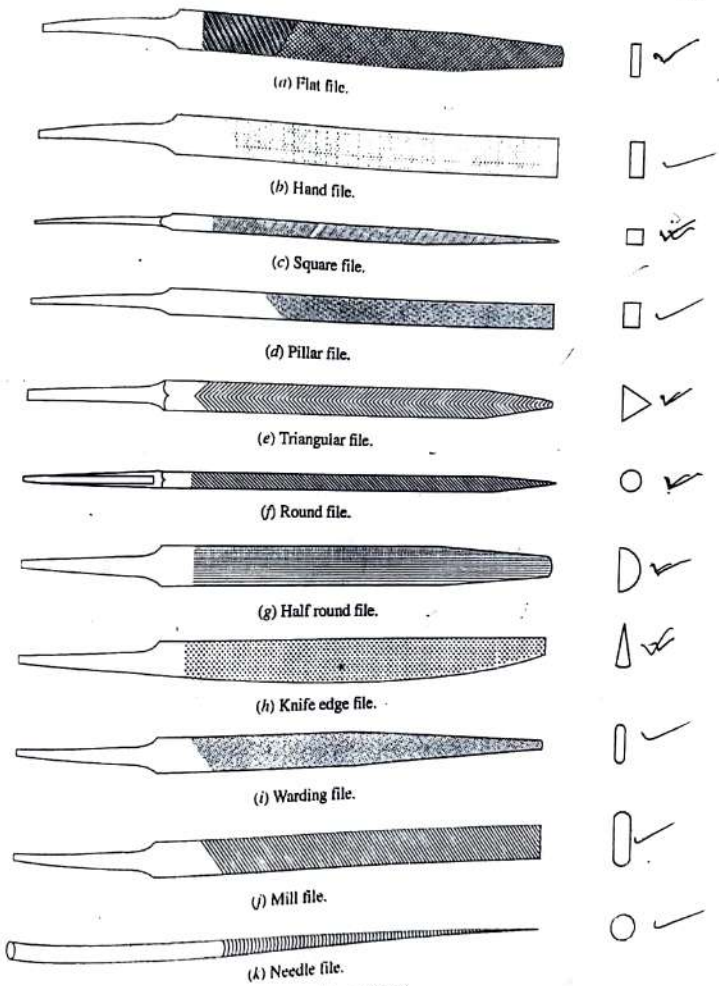


Fig. 16.14. Types of files

8. *Knife edge file.* A knife edge file, as shown in Fig. 16.14(*h*), has a width tapered like a knife blade. It is also tapered towards the tip and thickness. It is double cut on both flat faces and single cut on both edges. It is used for finishing sharp corners of grooves and slots.

9. *Warding file.* A warding file, as shown in Fig. 16.14(*i*), is similar to flat file but it is thinner and parallel on its thickness. It is used for filing narrow slots.

10. *Mill file.* A mill file, as shown in Fig. 16.14(*j*), is similar to flat file but parallel on both width and thickness and have both edges round. It is single cut and is suitable for forming the radius on saw teeth and in slots.

11. *Needle files.* The needle files, as shown in Fig. 16.14(*k*), are available in sizes from 100 mm to 200 mm of various shapes and cuts. These files are used for fine work such as pierced design in sheet metal.

16·11 Filing

Filing is required after chipping or cutting operation to remove burr and clean the face of the cuts and to finish the final shape ofthe work piece. It may be noted that not more than 0.6 mm should be left for filing. The filing operation consists of the following steps :

1. The work should be held firmly in the vice with the minimum amount of projection and with the surface to be filed truly horizontal.
2. The file handle is grasped in the right hand, as shown in Fig. 16.15, and the end of the file handle pressing against the palm of the hand. The pressure on the work is applied by holding the end of the blade with the left hand. The worker should take his position on the left side of the vice with the feet firmly planted, slightly apart.

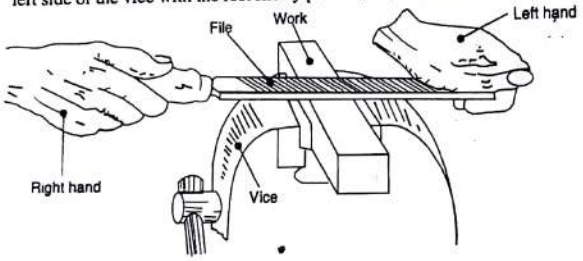


Fig. 16.15. Filing operation.

3. A stroke should be made by a slight movement of the right arm from the shoulder and h a sway of the body towards the work, each of these movements being about equal.
4. The file must remain horizontal throughout the stroke (which should be long, slow ar steady) with pressure only applied on the forward motion.
5. The file on the return stroke remains in contact with the work but the pressure is relieve from it.
6. In order to test the surface of work during filing, a straight edge should be placed on occasionally and the line of contact is viewed for day-light. When any considerable amou of metal has to be removed, the bulk of it should be removed by a rough or bastard-cut f and the surface progressively brought to a finish by second-cut and smooth files.

16·12 Method of Filing

The following three methods are commonly used for filing :

1. *Cross-filing.* It is the most common method of filing for general shaping work. It is us for efficient removal of maximum amount of metal in the shortest possible time. In this method, filing strokes run alternatively from left to right and from right to left as shown in Fig. 16.16, so t whole of file surface moves across whole of work surface in one stroke. In cross-filing the possibi

of rounding of surface is less and the scratch marks of the file teeth cross each other so that maximum amount of metal is removed.

2. *Straight filing.* It is specially useful on long and narrow pieces of work whose width is less than that of the file. In this method, the file stroke is made nearly at right angles to the length of work.

3. *Draw filing.* The draw filing is used to remove file marks and for finishing operation. During this operation, the file is gripped as close to the work as possible between two hands as shown in Fig. 16.17. It is moved lightly to and fro over the work. For this purpose, a fine cut file with a flat face (*e.g.*, mill file) should be used.

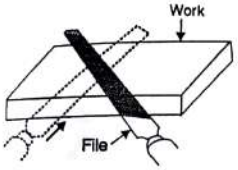


Fig. 16.16. Cross-filing.

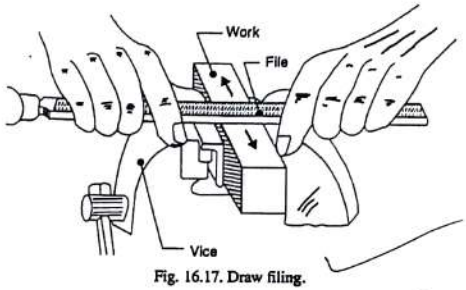


Fig. 16.17. Draw filing.

16·13 Care of Files

The following points should be kept in mind while using files :

1. The file should not be used without handle or with loose fitting handle.
2. A file should never be used on hardened steel, hard surface scale or allowed to strike against the hardened vice jaws.
3. The new file should be used first on copper, brass and then on wrought iron and mild steel.
4. Sometimes when soft metals are filed, they tend to clog the file teeth with minute particles of metal (called pins). A little consideration will show that these pins will not only stop the efficient cutting action but they also spoil the work with scratches. These pins are removed and the file is cleaned with a thin hard wire brush or a file card as shown in Fig. 16.18. After cleaning the file, chalk should be rubbed into the file teeth to prevent clogging of pins.

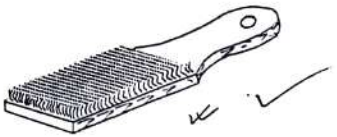


Fig. 16.18. File card.

5. The file should not be allowed to rust and to prevent it, the file is coated with machine oil. The oil should be removed before the file is put to use by carbon tetrachloride or caustic soda.
6. The worn-out files may be re-used by dipping it in hydrochloric acid. The worn-out files are best suited for making scrapers, punches, chisels etc.

16·14 Scraper

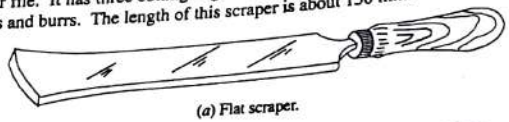
A scraper is a tool with sharp edge by means of which very small amount of metal can be removed. The process of removing metal with a scraper is known as *scraping*. Occasionally, it is carried out to improve the look or finish of surfaces.

The scrapers are made of tool steel or sometimes made from old worn-out files and provided with a wooden handle. The cutting part of the scraper is hardened but usually not tempered and then

ground with at least one sharp cutting edge. The scrapers are made in a variety of lengths fro 100 mm onwards and in many shapes. The various types of scrapers used are as follows :

1. *Flat scraper.* The flat scraper, as shown in Fig. 16.19(*a*), is the most common and simil to flat file. It has a cutting edge at the end which is slightly rounded. Its length vary from 100 mm 250 mm and width from 20 mm to 30 mm for rough work, 16 mm to 20 mm for accurate work and mm to 10 mm for extra accurate work. The thickness at the cutting end varies from 1 mm to 3.5 mm It is used for producing a perfectly flat surface.

2. *Triangular scraper.* The triangular scraper, as shown in Fig. 16.19(*b*), is made from wor out triangular file. It has three cutting edges. It is used for finishing small holes and for removin sharp corners and burrs. The length of this scraper is about 150 mm.



(*a*) Flat scraper.

(*b*) Triangular scraper.

(*c*) Half round scraper.

Fig. 16.19. Types of scrapers.

3. *Half-round scraper.* The half round scraper, as shown in Fig. 16.19(*c*), is made of h round file. It is used for scraping halves of bearings and curved surfaces. Its length is also about mm.

16·15 Method of Scraping

We have already discussed that the process of removing metal with a scraper to obtain a true flat surface, is known as *scraping*. Before scraping, it is necessary to establish the high spots or impressions on the work which require scraping. This is done by moving the surface of the work to and fro on the surface plate, the top of which is covered with a thin film of Prussian blue or red lead. The high spot marked on the surface of the work are now scrapped down by a scraper.

The method of holding a scraper is at approximately 30° to the work piece as shown in Fig. 16.20. The blade should be held in the left hand, close to the cutting edge. The handle is grasped by the right hand, with the thumb and first finger pointing in the direction of cutting edge.

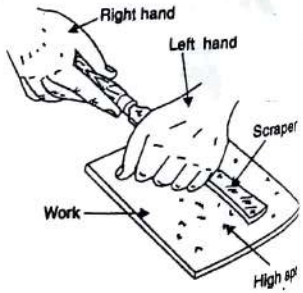


Fig. 16.20. Method of scraping.

16·16 Care of Scraper

Since the scrapers have a very sharp cutting edges, therefore, when these are not in use advisable to keep them lightly oiled and individually wrapped in a piece or cloth or felt or sil material, to protect the extremely hard cutting edge.

16·17 Grinding

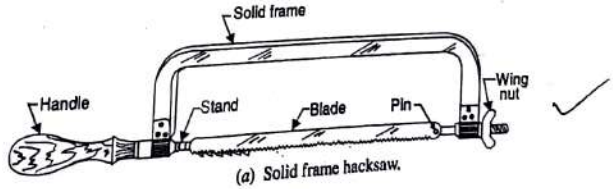
The grinding is the process of removing metal by the use of grinding wheels. The work for grinding is pressed against the grinding wheel which rotates at a comparatively high speed and the surplus metal is removed by abrasion. It produces extremely smooth finish due to the small cutting edges on the wheel. It can finish work to very accurate dimensions in a short time.

The grinding wheel is made of abrasive grains which form the cutting edges in a wheel. These abrasive grains are held together by some form of bond such as clay, shellac or rubber. There are two types of abrasives *i.e.*, natural abrasives and artificial abrasives. The natural abrasives are *corundum* and *emery* and the artificial abrasives are *silicon carbide* (the trade name is Carborundum) and *aluminium oxide* (the trade name is aloxite). The natural abrasives are tougher than artificial ones but not as hard. The artificial abrasives break with sharp clear fracture and thereby present new cutting edge to the work. The silicon carbide wheels are recommended for materials of low tensile strength such as cast iron, brass, leather, cemented carbide etc. The aluminium oxide wheels are best for materials of high tensile strength like hardened steel, high speed steel, alloy steel etc. The wheels made from coarse grained abrasives are used for fast removal of materials where as fine grained wheels are used for finish of work. The coarse-grained wheel may be used for grinding soft materials and fine-grained wheels for hard and brittle materials. The hardness or softness of the wheel depends upon the ability of the bond used to hold the abrasive grains in wheel against the tearing force. In order to dissipate the heat which is normally generated during grinding, a large amount of coolant over the work, wheel face and sides is generally used. This is known as *wet grinding* and it gives longer wheel life and high finish of work.

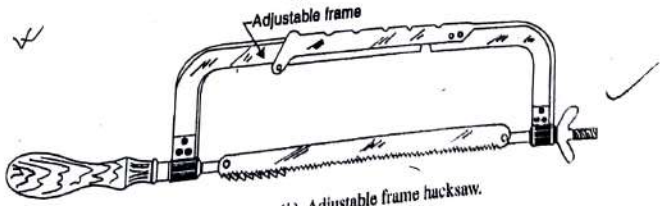
When the wheel becomes loaded or *glazed, it should be trimmed or dressed immediately to remove dull grains of abrasives and metal particles and to restore a sharp crystalline surface for efficient cutting.

16·18 Hacksaw

The hacksaw is the chief tool used by the fitter for cutting rods, bars and pipes into desired



(*a*) Solid frame hacksaw.



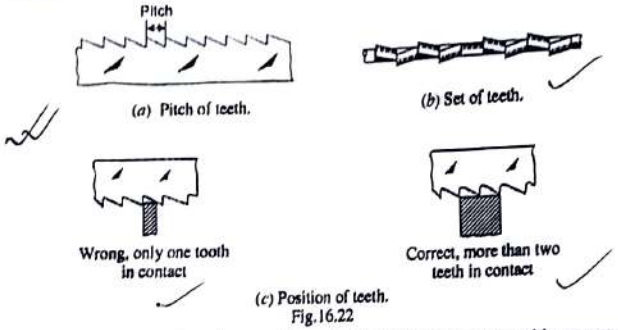
(*b*) Adjustable frame hacksaw.

Fig. 16.21. Types of hacksaws.

*The wheel is said to be loaded when the spaces between the abrasive grains become clogged with particles of material being ground so that cutting edges do not project sufficiently to do their work.

*The wheel is said to be glazed when grains which are worn down to the bond level have lost their sharpness are still detained by the bond.

lengths. It consists of a metal frame, which may be solid, as shown in Fig. 16.21(*a*), or adjustable, as shown in Fig. 16.21(*b*). The blade fits over two pegs which project from the pins sliding in the ends of the frame. The wing nut at the front end to the frame is for tensioning the blade. The blades are made of carbon or high-speed steel and may be finished with the cutting edge only hardened or they may be hard all over. The soft-backed blades are tougher and less liable to break than the all-hard blades. The blades are specified by its length and the point or pitch. The length of the blade is the distance between the outside edges of the holes which fit over the pins. The most usual blade for hand work is 250 mm long and 12.5 mm wide. The point or pitch is measured by the number of teeth per 25 mm length.



(*c*) Position of teeth.
Fig.16.22

The points of the teeth are bent, as shown in Fig. 16.22(*a*), to cut a wide groove and prevent the body of the blade from rubbing or jamming in the saw cut. This bending of the teeth to the sides is called the *setting* of the teeth as shown in Fig. 16.22(*b*). Usually alternate teeth are set to right and left, every third or fifth tooth left straight to break up the chips and help the teeth to clear themselves. The fine-toothed blades for cutting thin metal are sometimes made with a wavy set to minimize stripping of the teeth from the blade.

The choice of the blade for any particular class of work depends upon the pitch of the teeth and at least two or three teeth should be in contact with the surface being sawn, as shown in Fig. 16.22(c). If this is not attained, the teeth will be stripped from the blade and sawing too sharply over a corner will also result in teeth being torn off.

The best all-round blade for hand use is one with 16 to 18 teeth per 25 mm. For other special classes of sawing, the following blades should be used :

(*a*) 14 teeth per 25 mm, for solid brass, copper and cast iron.

(*b*) 24 teeth per 25 mm, for silver, steel and thin cast steel rods.

(*c*) 32 teeth per 25 mm, for sheet metal and tubing *e.g.*, steel, copper and conduit tubing.

The following should be kept in mind while using a hacksaw :

(*i*) The blade must be strained tightly in the frame and steady strokes (about 50 per minute) should be used.

(*ii*) The breakage of blades may be due to the following reasons :

(*a*) rapid and erratic strokes,

(*b*) too much pressure,

(*c*) blade held too loosely in the frame, and

(*d*) work not held firmly in the vice.

(*iii*) Solid metals should be cut with a good pressure and thin sheets and tubes with light pressure.

16·19 Power Hacksaw

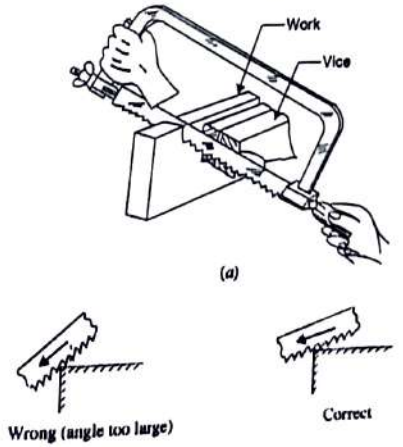
It is similar to ordinary hacksaw, but it has a motor driven attachment which moves the hacksaw blade to and fro. The power hacksaw has a special blade which is thicker and wider than ordinary blade. According to Indian standards (IS: 2594-1964), the length of the blade varies from 300 mm to 600 mm, width from 20 mm to 50 mm, thickness from 0.8 mm to 2.5 mm and pitch from 1.4 mm to 6.3 mm. It is used for cutting bars of diameter upto 200 mm or more. The cutting fluid should be used during cutting operation. The advantages of a power hacksaw are as follows :

1. It requires less time.
2. An unskilled worker can operate.
3. It automatically stops after cutting.
4. The accuracy can be maintained.

16·20 Sawing

It is the cutting and slotting operation and performed as follows :

1. The work is held tightly in the vice.
2. A suitable blade is fixed with its teeth facing forward so that it cuts the material in the forward stroke. The blade is tensioned sufficiently by a wing nut.
3. The course of the desired cut is marked by a guide line on the work and a nick or notch is made with a file.
4. The frame of the hacksaw is held, as shown in Fig. 16.23(*a*).



(*a*)

(*b*)

Fig. 16.23. Sawing.

5. Now the cutting is started at the nick by keeping the blade slightly inclined to the horizontal, as shown in Fig. 16.23(*b*). The pressure is applied during the forward stroke and it should be relieved during the return stroke.

Note : The tubes are not sawn in one go. First of all, the notch or neck portion is sawn upto the inner wall. Now it is rotated to such an extent that the saw blade is easily approachable to the saw cut. The process is repeated till whole of the tube is cut.

16·21 Measuring, Marking and Testing Tools

The following measuring, marking and testing tools as used in fitting shop are discussed as follows :

1. *Engineer's steel rule.* It is a stiff, straight steel strip having all the faces machined true. On one of the flat faces, graduations are marked in inches and centimeters as shown in Fig. 16.24. The least count in the former case is 1/64 of an inch and in the latter 1/10 of a centimeter. It is used to set out dimensions.

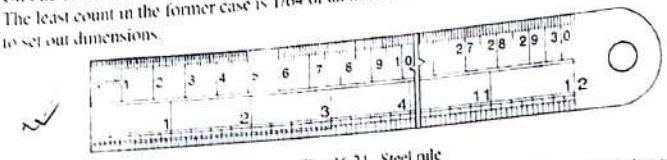
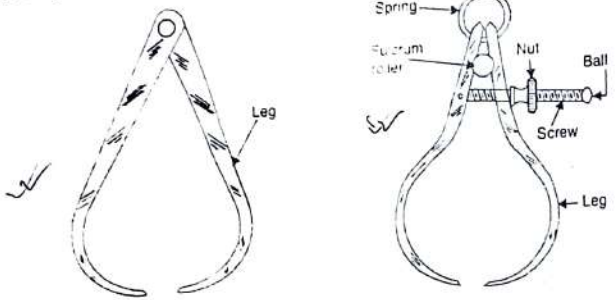


Fig. 16.24. Steel rule

2. *Outside calipers.* The outside calipers are of two types *i.e.*, ordinary or spring type. It has two steel legs which are bent inward as shown in Fig. 16.25. It is used to measure the outside diameter of round objects and to measure width and thickness. This is done by opening the legs and then measuring the distance between the legs with a steel rule. The ordinary calipers have the two legs hinged between washers for free movement. The spring callipers have a flat curved spring instead of hinge and the legs are moved with a screw which helps to keep the set dimension unaltered.

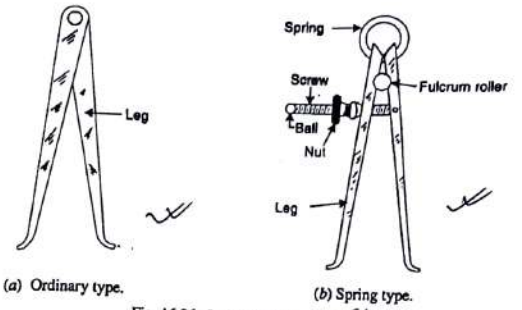


(*a*) Ordinary type. (*b*) Spring type

Fig. 16.25. Outside calipers.

3. *Inside calipers.* The inside calipers are also of two types *i.e.*, ordinary and spring type. These are similar to outside calipers, the only difference being that the legs are bent outwards as shown in Fig. 16.26. These are used to set internal dimensions, to transfer them to work or to check with standards.

4. *Hermaphrodite, Jenny or Oddleg caliper.* It is made of steel tapered strip which is hinged between washers at one end as shown in Fig. 16.27. One leg is bent at the tip inwardly and the other has a straight pointed end. It is used to find out the centre of a round bar by holding a bent leg against a curved face of the bar and the pointed leg on the end face. It is also used to scribe lines parallel to the straight edges or for taking distances from the edges of the holes or plates and similar jobs.



(*a*) Ordinary type. (*b*) Spring type.

Fig. 16.26. Inside calipers.

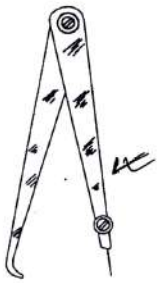


Fig. 16.27. Hermaphrodite caliper.

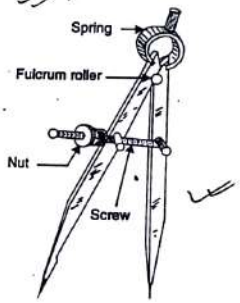


Fig. 16.28. Divider.

5. *Divider.* A divider is an important instrument used for marking work. It is similar to calipers but its legs have sharp points as shown in Fig. 16.28. The most common type of the divider used in fitting have spring arrangement. The dividers are used for measuring the distance between two points, dividing a given length in a definite ratio, drawing circles and arcs and transferring dimensions from scales to objects.

6. *Surface plate.* It is made of grey cast iron in various sizes. It is usually square or rectangular, as shown in Fig. 16.29, and has the top and the adjacent four edges very accurately machined and scraped to form a true flat surface and are brought in square. The casting is ribbed to prevent it from deformation. It is placed horizontally on a firm support whose working height is about 800 mm from the floor.

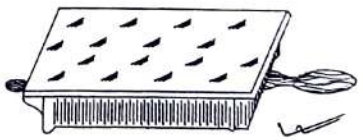


Fig. 16.29. Surface plate.

It is used to check the trueness of flat surfaces and to copy the master surface on a work. A thin coating of red lead mixed with oil is spread evenly over the surface plate. The work to be tested is cleaned, placed on the plate and gently moved along it. The parts which come in contact with red lead

are marked and show where more metal has to be removed. The surface plates are made in two grades of accuracy *i.e. A* and *B*, depending upon scraping of within 0.005 mm and 0.02 mm respectively. It should be oiled and covered with a wooden cover to protect from dust, when not in use.

7. *Scriber.* It is a round hardened steel piece of about 150 mm to 300 mm long and 3 mm to 5 mm in diameter. Its one end is sharp pointed and the other end is also sharp pointed but bent as shown in Fig. 16.30. The bent end is used to scratch lines in places where the straight end can not reach.

Fig. 16.30 Scriber.

8. *Scribing blocks.* These have round or rectangular base blocks made of cast iron. Following are the two types of scribing blocks :

(*a*) *Ordinary scribing block.* It consists of a cast iron sliding base on the centre of which a steel rod (spindle) is fixed vertically as shown in Fig. 16.31. A steel scriber, held in the holder, is made to slide, tilt and rotate, on the rod after clamping it with a set screw. It is normally used in conjunction with either a surface plate or marking table. Its specific use is in locating centers of round rods held in V-block.

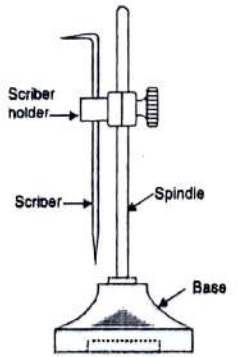


Fig. 16.31. Ordinary scribing block.

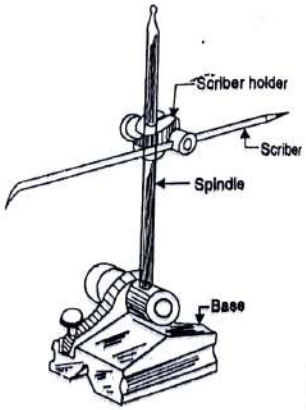
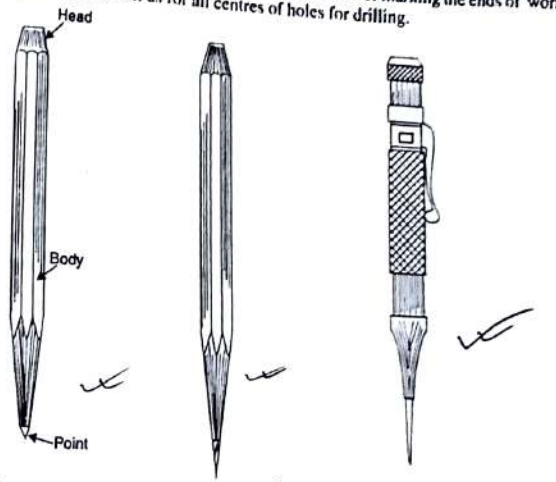


Fig. 16.32. Universal surface gauge.

(*b*) *Universal surface gauge.* It consists of a cast iron base perfectly machined and plane the top, bottom and all sides as shown in Fig. 16.32. It carries a spindle which may be set at any an A scriber, which may be set at any angle or at any height is clamped to the spindle. A fine adjustm is provided by a screw (height adjusting screw) and movement of this screw swings the scriber thro a small arc and thus varies the height. It is essentially used for marking on vertical or nearly ver surfaces, but it can also be adopted for scribing horizontal surfaces. A further advantage of this of gauge is the provision of a Vee in the base for resting the block on a round bar, so that the dimens may be set off from the bar to some other part of the work. It is used to find out the centre of a ro work, to align work in centre, and to layout markings on a work of any shape. The size of the g depends upon the job in hand but one with interchangeable spindles about 225 mm to 300 mm lo suitable.

9. *Punches.* A punch is primarily a marking tool used in bench work and is known as *centre punch*, as shown in Fig. 16.33(*a*). It is generally made from 10 mm octagonal cast steel about 100 mm long. One end of the punch carries a point ground to an included angle of 90° and is tempered to a pale straw colour while the other end (called head) is slightly chamfered to prevent it from burring. The body is knurled for gripping it by hand. It is used for marking the ends of work to be centred for turning in lathe as well as for all centres of holes for drilling.



(*a*) Centre Punch. (*b*) Prick or dot Punch. (*c*) Automatic centre punch.

Fig. 16.33. Types of punches.

The *prick or dot punch*, as shown in Fig. 16.33(*b*), is similar to centre punch but small in size. It is made from 6 mm diameter cast steel with a sharper point say 60 degrees. It is often used for marking position of lines and centres of circles to be drawn with the dividers.

The automatic centre punch, as shown in Fig. 16.33(*c*), is a hollow cylindrical body and has a spring loaded plunger by which a set blow is applied. The point of the punch is pressed against the work to be marked which compresses the spring inside. When the hand pressure is suddenly released, the spring in regaining its original length pushes the plunger downwards which applies a blow to the point. It is used for marking precision work.

10. *V-block.* The V-block is made of cast iron and all the faces are machined true. The two opposite side faces have V-grooves and the two have slots. The round bars are held firmly by a U-clamp engaging in slots, as shown in Fig. 16.34. The V-blocks are used for holding round bars during marking and centre drilling their end faces which are to be held between centres on lathe. It is also

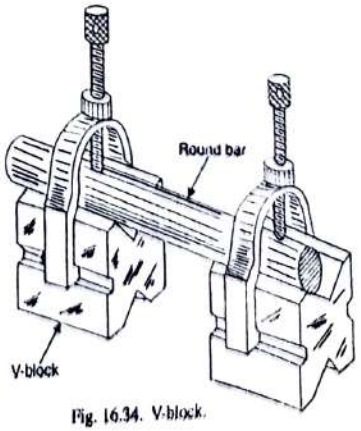


Fig. 16.34. V-block.

suitable for holding round bars while they are drilled at right angles to their axis.

11. *Angle plate.* The angle plate, as shown in Fig. 16.35, is made of cast iron in different sizes. It has two planed surfaces at right angles to each other and has various slots in both the surfaces to hold the work firmly by means of bolts and clamps. The angle plate is used in conjunction with the surface plate for supporting work at right angles for marking.

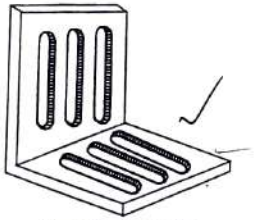


Fig. 16.35. Angle plate.

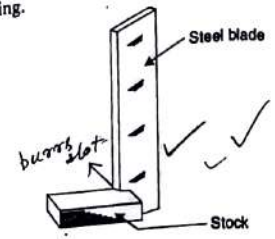


Fig. 16.36. Try square.

12. *Try square.* It consists of a steel blade fixed at right angles to the edge of a machined stock of cast iron as shown in Fig. 16.36. It is used for testing the squareness of surfaces and to set off lines at right angles to a given edge.

13. *Combination set.* It is an extremely useful too. It incorporates all the essential features of the try square, protractor, spirit level, rule and scriber. The combination set, shown in Fig. 16.37, consists of four parts *i.e.* square head, protractor head, centre square head and a blade or rule on which the other three parts slide. They are located in a groove in the blade and a tongue in the head to which the clamping screw is attached. The protractor and square heads are usually provided with spirit levels. The square head has a small scriber concealed in the end.

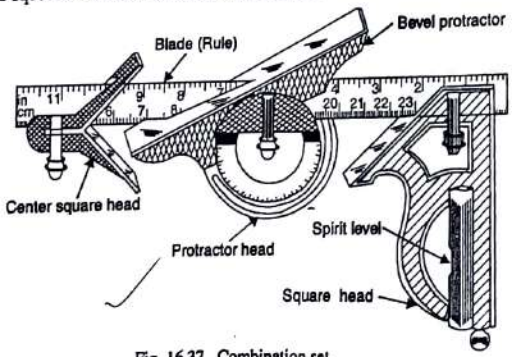


Fig. 16.37. Combination set.

The square head can be used, by moving the blade, as a try square, as a metre square or even a depth gauge.

The centre square head may be used to extend a line around a corner, to find centre of a round piece or to find the centre at the end of a shaft. The protractor head is used for measuring angles and can be clamped in any desired position. The scale is graduated in degrees.

14. *Trammel.* A trammel, as shown in Fig. 16.38, is an alternative to dividers and it is used where a large circle having a large radius is to be marked. Since it has two adjustable vertical legs mounted on a common rod (called beam), therefore it is also known as *beam compass* or *beam*

trammel. It may also be used to measure distances in the same way as a divider is used.

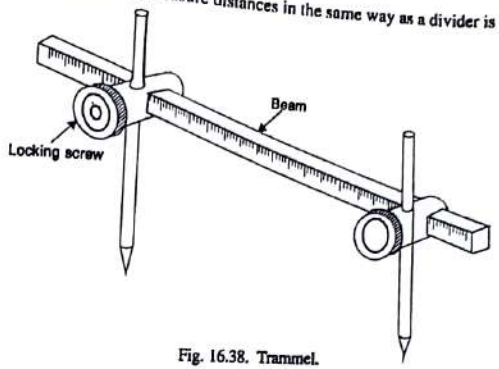


Fig. 16.38. Trammel.

15. *Straight edge.* The straight edge, as shown in Fig. 16.39, is like a solid bow. It is made of cast iron, ribbed at intervals and has machined straight flat edges made true. The ribbing is done to prevent warping. These are made of varying widths and lengths. It is used for testing the straightness and flatness of plane surfaces, particularly to test the accuracy of the ways of a lathe, planer, shaper etc.

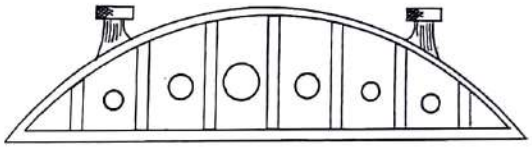


Fig. 16.39. Straight edge.

16-22 Method of Marking

The marking on a work is the most important operation in the bench work, in order to obtain an accurately finished product. It consists of setting out the dimensions on a work from the working drawing or transferring them from a similar part. The following procedure is adopted for marking on a work :

1. First of all, the surface of the work is coated with a paste of chalk or red lead and allowed to dry.
2. If the work is flat, it is laid with its uncoated surface on the face of the surface plate and if it is round, it is held in a V-block and clamped as shown in Fig. 16.34. In case the work is too thin, it is normally supported against an angle plate keeping the surface to be marked at right angles to the surface of surface plate.
3. Now the horizontal lines are first scribed by means of scribing block or surface gauge. The vertical lines are drawn by turning the work through 90° and by using the scriber. If a true surface is available on the edge of the work to be marked, then the horizontal and vertical lines may be marked with the help of a try-square.
4. The centre on the end of a round bar may be located by using a hermaphrodite caliper, surface gauge or a combination set.
5. The circles and arcs on a flat surface are marked by means of a divider.

6. After the scribing work is over, light indentations are made along the scribed lines, centres of circles and arcs, by means of a dot punch and a hammer. These punch marks serve as a guide for further operations like filing, chipping, drilling etc. During these operations, the metal is removed upto half the circumference of these punch marks to ensure that the job has gone undersize.

16·23 Drilling Tools

The drilling tools called drills are used for making round holes in the work. The following three types of drills are commonly used :

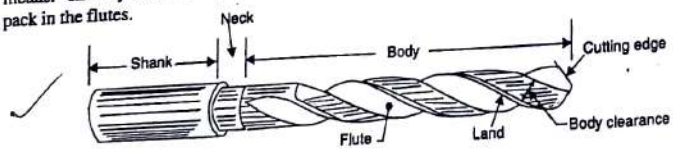
1. *Flat drill.* It is a simple type of drill and has two cutting edges bevelled at 60°, as shown in Fig. 16.40.

Fig. 16.40. Flat drill.

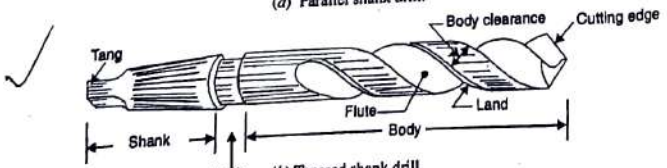
It is easily made by flattening a round bar of tool steel at one end by forging. It is then ground, hardened and tempered. The flat drill can not be used to drill deep holes because the chips (*i.e.* cut material) do not come out of the hole during the operation. The cutting edge of the drill wear quickly due to the metal chips remaining in the hole and by grinding every time, the diameter gets reduced. Strictly speaking, the flat drill can never be relied upon to give accurate straight hole.

2. *Straight fluted drill.* The straight fluted drill, as shown in Fig. 16.41, is used for making holes in brass, copper and other soft metals. Its only disadvantage is that the chips pack in the flutes.

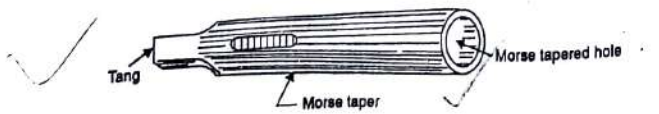
Fig. 16.41. Straight fluted drill.



(*a*) Parallel shank drill.



(*b*) Tapered shank drill.



(*c*) Drill sleeve.

Fig. 16.42. Twist drills and drill sleeve.

3. *Twist drill.* It is the most commonly used variety of drill and is made with two, three or four cutting lips. The two lip drill is used to drill holes into solid metal while the three and four lip drill is used for enlarging holes previously drilled. The twist drills, as shown in Fig. 16.42(*a*) and (*b*), has a cylindrical body on which the grooves are cut.

These grooves are called *flutes*. The flutes of a twist drill are always made with a right hand helix. This forces the chips up the flutes and away from the cutting edges. While drilling, the drill is held by the shank. The shank may be parallel or tapered, as shown in Fig. 16.42(*a*) and (*b*) respectively. The parallel shank is provided on small sized drills (*i.e.*, upto 12.5 mm). The tapered shank drills have a taper called the *morse taper*. The size of taper on any particular drill depends upon the drill diameter. These drills are provided with a *tongue* (also called *tang*) at the end of the tapered shank. The drill is held by the shank while drilling. The shank fits into the slot in a drill sleeve, as shown in Fig. 16.42(*c*) or in the machine spindle. It drives the drill and keeps the shank from slipping especially on large drills.

The drills are taken out from the machine spindle with the help of a drift, as shown in Fig. 16.43. The drills are made of high speed steel containing 18 percent tungsten, 4 percent chromium and 1 percent vanadium.

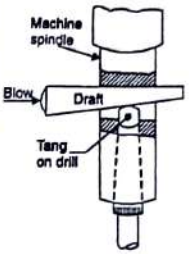


Fig. 16.43. Use of a drift.

16·24 Various Angles of Twist Drills

The various angles of twist drills, as shown in Fig. 16.44, are discussed as follows :

1. *Cutting angle or angle of lip.* The two lips must be of the same length and the angles of both lips must be equal. The cutting angle for ordinary work is 59° and varies with the metal to metal.

Notes : (*a*) If the cutting angle is more, the drill will not cut the metal easily and will not hold its position centrally because of being too flat.

(*b*) If the cutting angle is less, more power will be needed to turn the drill and the drill will cut at a slower rate due to the longer cutting edges.

(*c*) If the angles on the cutting edges are different, then one cutting edge will wear quickly and the hole will be larger than the drill. This results in the wobbling of spindle and the drill wears out quickly.

2. *Lip clearance angle.* It is the angle formed by grinding away the heel (it is the part of the point) behind the cutting edge. The cone shaped cutting end is the point from the lips and varies from 12 to 15 degrees. This angle may be increased for drilling soft materials under heavy feeds. In cases of drilling the hardest material, this angle is 9 degrees and if it is reduced further, the drill cannot cut into the metal and may break in the centre along the web.

3. *Rake angle.* It is the angle between the flute and the work. It is usually 70 to 75 degrees. This helps to secure the lip over the correct space to curl the chips. If this angle is more, then there will be no edge for cutting and if it is less, the cutting edge is too thin and may break under the strain of the work.

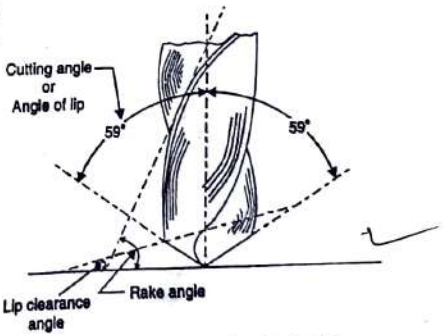


Fig. 16.44. Various angles of twist drills.

16·25 Drilling Machines and Appliances

The most common drilling machine used in fitting shop is a sensitive drilling machine which may be either bench or pedestal mounted type. A vertical drilling machine, as shown in Fig. 16.45, consists of a base, adjustable table electric motor, drill spindle, pulleys, belt and column. The machine is usually provided with four to six speeds. The speed can be varied by changing the position of Vee-belt on the pulleys. The driving motor is generally of 0.5 H.P.

The hand-drilling appliances for holes are used where it is not possible to bring the work up to a machine. The following four types of hand-drilling appliances are mostly used.

1. *Hand or wheel brace.* A hand brace, as shown in Fig. 16.46(*a*), is operated by hand and is used only for small drilling operations (*i.e.*, for drilling upto 6 mm diameter). It has a main framework of metal with a wooden top. The centre of the frame carries a bevel wheel and a handle. This bevel wheel is meshed with a small pinion mounted on a spindle in the lower part of the frame. The screw-threaded end of the spindle carries a tapered chuck or drill holder with an opening at the end to accommodate a drill. The chuck contains three sliding jaws held apart by spiral springs. These jaws are tapered on the outside to correspond with the inside of the chu When the chuck is screwed further on to the spindle the jaws are forced towards the opening at

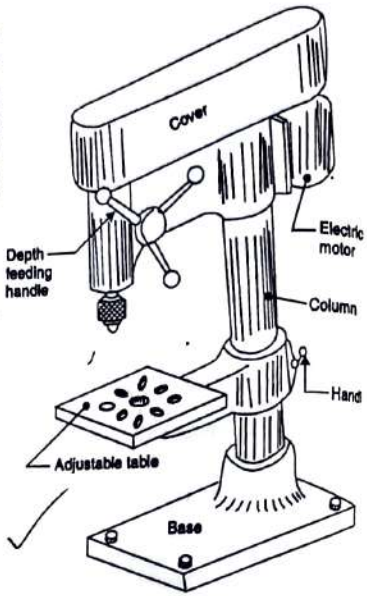
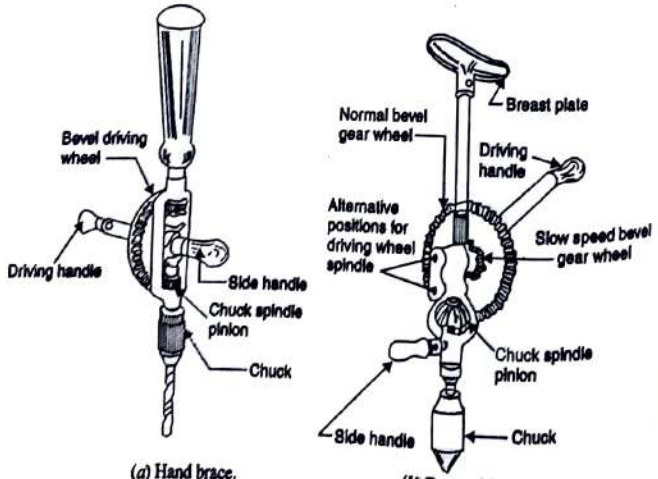


Fig. 16.45. Vertical drilling machine.



(*a*) Hand brace. (*b*) Breast drill.

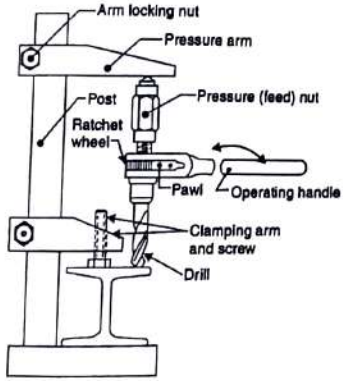
Fig. 16.46. Hand drilling appliances.

end of the chuck and due to the taper the jaws are made to close and grip the drill. In order to open the jaws, the chuck is turned in the opposite direction releasing the pressure and allowing the springs to open the jaws.

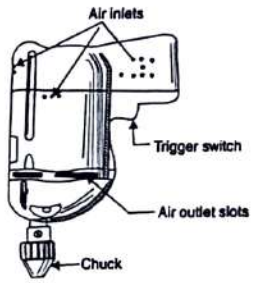
2. *Breast drill.* A breast drill, as shown in Fig. 16.46(*b*), resembles the hand brace and works on the same principle, but it is larger and more sturdy in construction. It may be used for holes upto 12.5 mm dinmeter. The top of the frame is fitted with a T-shaped metal plate which is curved to fit the chest. The pressure is given by the body, leaving the left hand free to steady the drill by the small handle fitted to the lower part of the frame.

Some breast drills are fitted with an additional smaller bevel wheel to lower the speed at which the spindle rotates. This is an advantage when holes have to be drilled in metals which require slower cutting speeds. In order to change the speed, the spindle of the bevel driving wheel is fitted in the lower hole in the drill frame bringing the small bevel wheel in contact with the chuck spindle pinion.

3. *Ratchet brace.* A ratchet brace, as shown in Fig. 16.47(*a*), has the following advantages, though the drilling a hole with ratchet brace is a slow process :



(*a*) Ratchet brace.



(*b*) Electric hand drill.

Fig. 16.47. Hand drilling appliances.

1. It can drill holes of large diameter which are beyond the range of a hand or breast drill.
2. It can be used where power is not available.
3. It can be clamped to any suitable support or part of a machine at any suitable angle.

In its operation, the operating handle is moved in a short arc clockwise, which engages the pawl in the ratchet and rotates the drill. The handle is then drawn back to make the next stroke and the pawl slips over the ratchet. The pressure is gradually applied as the drilling proceeds by turning the large hexagonal nut about the ratchet. The taper or square shank drills may be used depending upon the type of drill holder fitted.

4. *Portable electric hand drill.* The portable electric hand drills are used for quickness of drilling operation. The small types of portable electric drills are usually pistol shaped as shown in Fig. 16.47(*b*). The current is passed to a small electric motor contained in the main casing and the armature is extended to drive the spindle and gear assembly carrying the chuck. A trigger or button switch is provided to control the current. The chuck principle is similar to that of hand brace except

that in some types a toothed key is used which engages with the teeth on the chuck to open and close the jaws. A small portable electric drill is used to drill holes upto 6 mm diameter.

The large portable electric drills are similar in construction except that power of the motor is passed through additional gears to reduce the chuck spindle speed. This is necessary because low cutting speeds are required for larger diameter drills.

16·26 Drilling

The operation of making round holes in metal pieces is known as drilling. It is done with the help of a drilling machine. There are many types of drilling machines, but the most common drilling machine used in fitting shop is a vertical drilling machine, as shown in Fig. 16.45.

The drilling operation is carried out as discussed below :

1. First of all, the work is marked with a centre punch at the centre of the hole to be drilled.
2. It is then firmly held in a vice or other suitable clamping device and placed on the adjustable table of the drilling machine.
3. The drill is fitted in the chuck.
4. The spindle with the chuck is lowered by the hand lever and it is ensured that the point of the drill is in exact alignment with the previously marked centre of the hole.
5. The motor is now started and the rotating drill is gradually pressed into the work to produce the desired hole.
6. The pressure should be frequently relieved during the drilling operation, otherwise the cutting edges of the drill will be strained and the drill is damaged.
7. In order to avoid the spoiling of cutting edges of the drill, a coolant such as oil or soap water should be used constantly during the drilling operation. The coolant is not required while drilling in brass and cast iron.

16·27 Reamers

In order to produce a hole having sufficiently good qualities of finish and accuracy for many purposes, and when accurate holes are required, a *reamer* must be used for finishing to size. The reamer does not originate the hole in the same way as the drill, but it merely imparts the necessary smoothness, to the previously drilled hole, parallelism, roundness and accuracy in size. The reaming however, will not correct any errors which may be in the hole with regard to its position, or direction because the reamer merely follows the previously drilled hole. The various types of reamers commonly used for finishing the drilled hole are as follows :

1. *Hand reamers.* The hand reamers are operated by hand with a *tap wrench fitted on the square end of the reamer, with the work held in the vice. These reamers cut on the flutes which may be straight or helical and are tapered at the end for about one-fourth of its length. The extreme free end diameter is about 0.25 mm less than the reamer size. The shank is slightly less than the diameter of the flutes. A straight fluted hand reamer is shown in Fig. 16.48(*a*). The reamers are supposed to remove the minimum amount of metal *i.e.*, from 0.05 mm to 0.1 mm. If too much metal is allowed to remove by the reamer, then the edges of the reamer rapidly wear and lose their size. The finished hole may also be of over size and inaccurate. The hand reamers are usually made of cast steel.

2. *Machine or spiral fluted reamers.* The solid fluted reamer is similar to the hand reamer but it has a tapered shank. These reamers may have straight flutes, but more often they are cut with left-hand helix, as shown in Fig. 16.48(*b*). The angle made by the flute with the length of the reamer varies from 4 degrees to 8 degrees. The flutes are made left-hand to counter act the tendency of reamer would have to screw itself into the hole if the flutes are right-hand and even the straight-flu

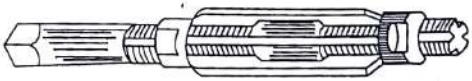
* See Fig. 16.49 (*d*).

reamers have a slight tendency to draw in. The machine reamers are usually made of high speed steel.

3. *Expanding reamers.* When a solid reamer becomes worn, it must either be ground down to the next smaller size or the teeth slightly enlarged by softening the teeth, expanding them slightly by hammering their fronts with a punch, re-hardening and grinding up again to size. In order to avoid this, expanding reamers are used. These are of various types, a common one is shown in Fig. 16.48(*c*). When the reamer has lost its size the diameter of the flutes is increased slightly by springing them open with a tapered pin operated by an adjustable screw, after which they are re-ground to the correct size.

(*a*) Straight fluted reamer.

(*b*) Machine reamer (spiral fluted).



(*c*) Expanding reamer.

Fig. 16.48. Types of reamers.

16·28 Reaming

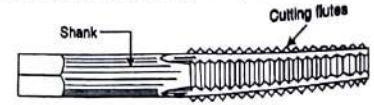
The reaming is a process of imparting necessary smoothness, parallelism, roundness and accuracy in size, to the previously drilled hole by using a reamer. The reaming does not correct any errors which may be in the hole with regard to its position or direction because the reamer merely follows the previously drilled hole. The hand reaming is mostly done when exactness is required. In this operation, the work is held in a vice and the reamer is placed into the hole which is operated by a tap wrench fitted on the square end of the reamer. Before starting the reaming, it must be ensured that the reamer is square with the axis of the hole being reamed. In order to obtain best results, reamer should be given a slow and steady motion and lubrication may be used. The reamer is turned only in clockwise direction even when it is removed from the hole.

16·29 Taps

A tap is used for cutting internal threads into a hole. The tap is provided with cutting edges and hardened, so that when it is screwed into a hole it cuts an internal thread to fit an external thread of the same size. The taps are made of high carbon or high speed steel by turning a screw and then cutting flutes along it in order to provide cutting edges which is used to screw it into the hole. After hardening and tempering, the flute at the front of the threads is ground up to provide the necessary sharpness on the threads for cutting. The shank of the tap is left plain and the end is squared to accommodate the tap wrench, as shown in Fig. 16.49(*d*).

The taps are usually made in sets of three to cut any particular size. These are called taper, intermediate (or second) and bottoming (or plug). The *taper tap* as shown in Fig. 16.49(*a*) has its leading end tapered off for a length of 8 to 10 threads and this is the first tap to use. The tapered end permits the tap to enter the hole and cut to the full thread gradually. The *second tap*, as shown in Fig.

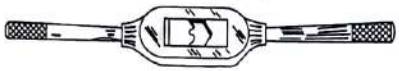
16.49(*b*), has only two or three threads chamfered and follows the taper tap. If a hole is open at both ends, this tap is suitable for finishing the thread in it. The thread on the *bottoming or plug tap*, as shown in Fig. 16.49(*c*), runs to its extreme end and this tap should be used as the final tap, when a full thread must be cut to the bottom of a blind hole (*i.e.*, only open at one end).



(*a*) Taper tap.

(*b*) Second tap.

(*c*) Bottom (or plug) tap.



(*d*) Tap wrench (adjustable).

Fig. 16.49. Taps and tap wrench.

16·30 Tapping

The process of cutting internal threads into a drilled hole by using a tap is known as tapping

For tapping, the following procedure is adopted :

1. First of all, a hole is drilled to a diameter smaller than the outside diameter of the thread of the tap *i.e.*, equal to the core diameter. The diameter of the hole to be drilled is called *tapping size* Mathematically,

$$\text{Tapping size} = \text{Outside diameter} - 2 \times \text{Depth of thread}$$

where $\text{Depth of thread} = 0.64 \times \text{Pitch of thread}$

2. After drilling the tapping hole, the taper tap is fixed in the tap wrench and screwed in the hole. Before commencing to screw it round for cutting the thread, the tap position must be adjusted until it stands square with the tap surface of the work and it must be maintained square.

3. For all materials except cast iron a little whale oil on the tap is applied to lubricate the action and improve the finish of the threads.

4. When the taper tap is felt to have started its work and its squareness has been checked, the cutting of threads proceeds. It should be kept in mind that the tap is not turned continuously, but after every half-turn it should be reversed slightly to clear the threads.

5. When the hole is straight through, the reduction of resistance indicates the taper tap cutting a full thread and it may be removed from the hole which may be finished with the second tap.

6. When a blind hole is being tapped, the tap should be withdrawn from time to time and the

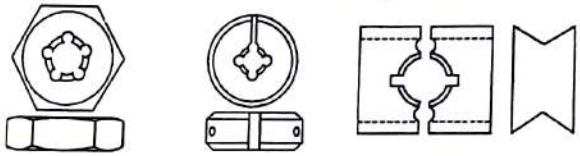
metal cleared from the bottom of the hole. When the end of the tap reaches the bottom of the hole some resistance will be felt and no further force should be used at this point as the tap may be broken or the thread spoiled. Remove the taper tap and take the second one down as far as it will go and finally threads are cut at the bottom of the hole with a plug tap.

Note : When large number of holes are to be tapped, the hand tapping is a slow process. In such cases, the tapping is done by driving the tap with the drilling machine running on slow speed. This is called machine tapping.

16·31 Dies and Stocks

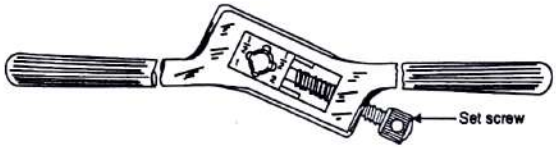
A tool used for cutting external threads on bars or tubes is called a *die*. It consists of a nut having portions of its thread circumference cut away and shaped to provide cutting edges to the remaining portions of the threads. After hardening and sharpening of the cutting edges, this is screwed on to the bar upon which the thread is to be cut. In order to hold and manipulate the die it is carried in the centre of a pair of operating handles called *stocks*.

A *solid die nut*, as shown in Fig. 16.50(*a*), is not usually employed for cutting threads from the solid but is used to rectify damage and knocks to existing screws such as on studs or bolts. They have usually five or more cutting edges and there is no means for adjustment.



(*a*) Solid die nut. (*b*) Circular die. (*c*) Split die.

(*d*) Stock for circular die.



(*e*) Stock for split die.

Fig. 16.50. Dies and stocks.

The *circular dies*, as shown in Fig. 16.50(*b*), cut the threads in one operation and permits a certain amount of adjustment in the size that the die will cut. This is done by a small amount of opening or closing of the die with the help of screws in the stocks, as shown in Fig. 16.50(*d*).

The *split dies*, as shown in Fig 16.50(*c*), consist of a pair of dies or jaws which fit into the stocks, as shown in Fig. 16.50(*e*), and are clamped by a screwed ring. These dies slide and may be adjusted by screws which bear against their outer faces. This permits the dies to be set a small amount open while the first cut is taken down a bar and closed into the correct size for the final finishing cut.

FITTING

INTRODUCTION:-

In engineering bench work and fitting have important role to play to complete and finish a job to the desired accuracy . The term “bench work” denotes the production of an article by hand on the bench. Although the job can be finished to a fairly good degree of accuracy through machine operations, still they often require the hand operations to be done on them to finish them to the desired accuracy. Fitting is the assembling together of the parts and removing metals to secure the necessary fit and may or may not be carried out at the bench. An operator who does the fitting job is called “fitter” and the operation done by him is called “fitting”.

SAFETY PRECAUTION:-

Before entering the workshop all are bound to adopt the safety precautions rule strictly to avoid any possible accidents. Many of the accident occur due to carelessness and individuals. Hence the safety precaution rules should be followed strictly.

Some simple pints but they are the main causes for the accidents are ---

1. Improper dress.
2. Poor judgment.
3. Lack of interest.
4. Ignorance.
5. Fear.
6. Over confidence.
7. Worries.
8. Dullness.
9. Insufficient space.
10. Poor physical fitness.
11. Improper Handling of tools, machines, fire, electricity etc.

Workshop Safety Rule:-

1. Keep the workshop tidy and clean.
2. Wear tight clothes. Loose clothing or long hair will bring danger.
3. Do not run, shout, knock, smoke, inside the workshop.
4. Wear covered footwear. Never use rubber sandals.
5. Never place sharp materials such as snips, scriber, scrapers, scraps on the floor.
6. Place the heated job under the board. Write don't touch.
7. Store the inflammable materials such as oil, grease, etc. away from the workshop.
8. Shout or ring the alarm bell before the accident spread over.
9. Remember that a slippery floor is always dangerous.

Keep up the fire bucket and extinguishers **ready** for use.

Hand tools safety rules:-

1. The right tools should be handled carefully and correctly.
2. Place the tools in the proper place in the perfect manner.
3. Never use files, screwdriver, scrapers etc. without the handle.
4. Check up the hammer whether it is wedge well. Don't use a cracked handle.
5. Remove oily substance on the face of the hammer and the top of the chisel while working with it.
6. Wear goggles and place chipping screen while chipping.
7. Don't use mushroom headed chisel.
8. Never store more tools at the working spot. Keep up the unwanted tools safety in the tool kit box.

Machine safety rules:-

1. Don't start any machine before getting any instruction or permission.
2. Never operate a new machine unless you know thoroughly of it.
3. Never work on unguarded machine.

4. If any machine produced unusual sound, stop it immediately and report.
5. Never apply more load beyond the capacity on the lifting appliances.
6. If any machine is not in working condition, fit a board “under repair” on the machine or disconnect the power supply.
7. The operator should not leave the machine while running automatically.
8. Call electrician for electrical fault.

Personal Safety Rule:-

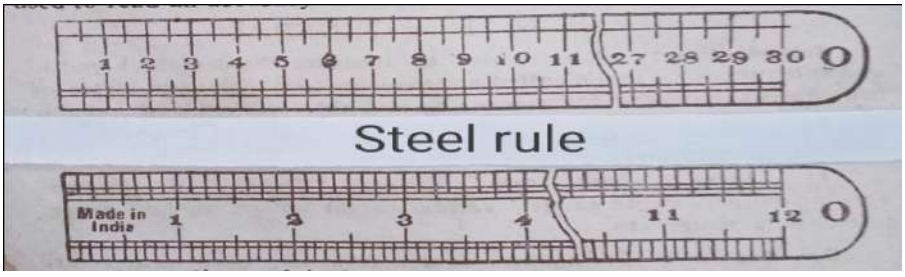
1. Protect yourself first and never fail to give protection to the machine.
2. Wear tight dress and insert your shirts.
3. Do not wear a ring or a watch while working.
4. Wear goggles while on chipping or grinding.
5. Never clean the chips by bare hands.
6. Cleaning, lubricating, and mounting the belt **should** be avoided while the machine is in running motion.
7. Before having sufficient man power, do not try to load or unload any heavy weights.
8. Though the accident is little, do not hesitate to take treatment from a doctor.

TOOLS AND EQUIPMENTS:-

Steel Rule

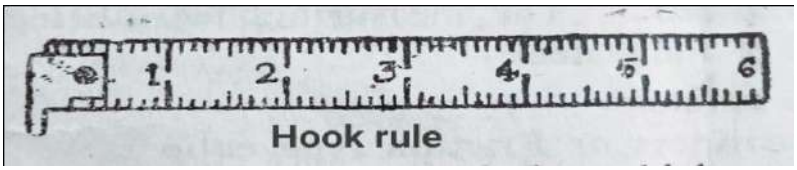
A Steel Rule is a direct measuring instrument used to read an accuracy of 0.5 mm and 64ths of an inch available in various lengths, widths, and thickness with several styles of graduations.

They are made from high carbon steel, stainless steel and various alloy steels.



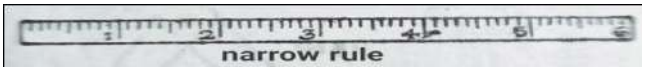
Various Types and Uses:-

a. **The Standard Rule**:-It is used to measure the simple components to an accuracy of 0.5 mm. or 64ths, 32nd, 16ths of an inch. It is available in 150mm, 300mm long with both graduations of Metric and English. It is more useful for all the general purposes.
b. **The Steel Tape:-**It is used for measuring the lengthy bar to an accuracy of 1/8 inch. It is available in 6ft, 25ft, 50ft and 100ft long with metric graduations also.
c. **The Flexible Rule:**-It is used to measure straight and curved components to the close limits to an accuracy of 0.5 mm and 64ths of an inch.
d. **The Hook Rule:**-It is very convenient for taking the measurements on flanges, circular pieces, hubs, pulleys etc. It is also used for setting the calipers, and dividers as well as the lengthy holes which cannot be seen by the users.



Hook rule

e. **The Narrow Rule:**-It is used to measure the slots and small deep holes to an accuracy of 64th of an inch. The width of the rule is 0.5 mm or 7/32 inch. So it is called a narrow rule.


narrow rule

f. **The Shrink Rule:**-It is designed for laying out, wood and metal patterns; core boxes etc for the moulders. It is graduated conveniently to give shrink allowance directly according to the shrinkage of metal.

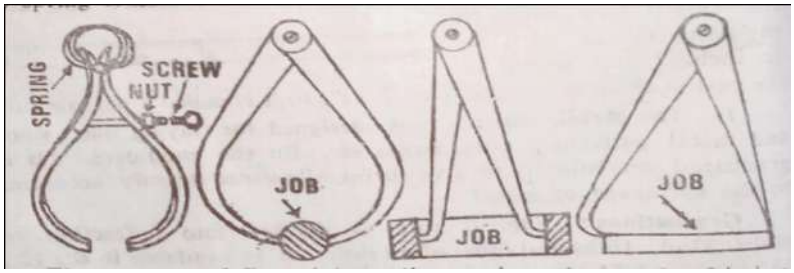
CALIPER

Introduction:-A simple tool equipped with gauging leg is called calipers. After taking the measurement with sensitivity of feel or touch, it is transferred to a steel rule for reading.

Material:-It is made of high carbon steel. The measuring points are hardened and tempered.

Types:-1] Spring type calipers.

2] Firm joint calipers or Friction type calipers.



Kinds:-1] Outside calipers [Spring and Friction]

2] Inside calipers [Spring and Friction]

3] Jenny calipers [Spring and Friction]

Uses:-1] The outside calipers are used to measure the outer dimensions of shaft, pulleys , square bars etc.

2] The inside calipers are used to measure the inner dimensions of holes, bores, slots etc.

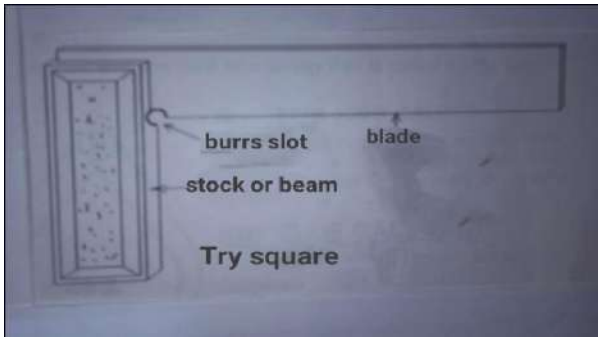
3] The Jenny calipers are used to layout work for locating and testing centre on cylindrical and other sections laying of distance from an edge and to scribe parallel lines. Leg and points hermaphrodite, odd leg, murphy are the other names to jenny caliper.

Classification:-It is classified according to the greatest distance that can be opened between the two measuring faces and the types. [Eg] Caliper outside 150 mm spring type [I.S.I.]

TRY SQUARE

Introduction:-It is a marking and checking instrument of right angles. It is made of a beam and a blade as specialized equipment and each straight edge is checked for conformity to great accuracy of right angle i.e. 90 degree.

Material:-The stock is generally made of cast iron, and the blade is made of high carbon steel, hardened and tempered.



Uses:-It is used to check up the right angles of the job as well as the even flatness of the surface. It is also used for marking right angles.

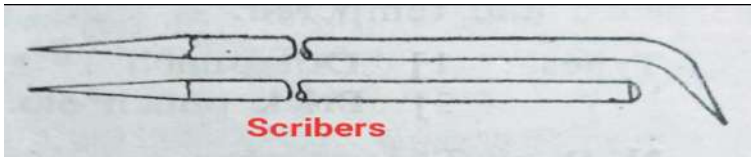
Classification:-It is classified by the length of the blade. { Inner edge of the stock to the end of the blade.}

Checking of trueness:-1] Select an even surface of a true edged material say a surface plate. Place the try square pressing the stock against the outer edge and mark a line along the side of the blade. Turn the stock of the try square oppositely and check up the marked line or scribe another line. If the both lines are coincided or parallel, it is confirm that the try square is a true one.

2] The trueness of a try square can also be checked by a master square, which is kept in a protected box safely by the inspection department.

SCRIBER

Introduction:-The scriber is a pointed tool used for marking line on metals. It is available in various lengths of 150, 200, and 250 mm. It has a sharp point and is ground to an angle of 12 to 15 degree. The handle has a knurled grip.



Material:-Scriber is made from high carbon steel and the points are hardened and tempered.

Types:-1] Straight scriber

2] Bent type scriber

3] Off-set scriber

4] Adjustable sleeve scriber

5] Knife point scriber etc.

Uses:-Scribers are used to marking on metal. The bent type scriber is used for scribing lines into the hole.

DIVIDER

Introduction:-The tool consists of two pointed legs having a joint at the top end. Firm joint and spring type dividers are available.

Material:-It is made from high carbon steel and the points are hardened and tempered.

Uses:-1] To scribe circles, arcs, parallel lines and laying of distances. 2] To divide the straight or curved lines in to a number equal spaces. 3] To find the centre of round bars. 4] To transfer the dimensions from a rule to job. Etc.

Classification:-It is classify according to the size measured by the greatest distance it can be opened between two legs. Divider 100 mm spring type [I.S.I.]

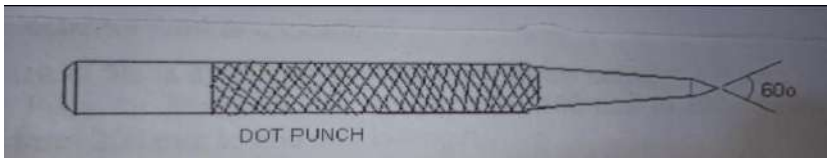
PUNCHES

Introduction:-It is a cylindrical steel piece. The parts are head, body, shank and point. The point is ground at the proper angle to give maximum services. The body has a knurled finger grip.

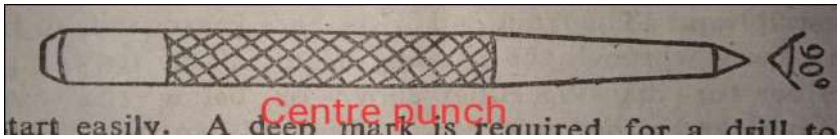
Material:-It is made from tool steel and the point is hardened and tempered. The punches using for other purposes are also available.

Types:- 1] Dot punch. 2] Centre punch. 3] Prick punch.

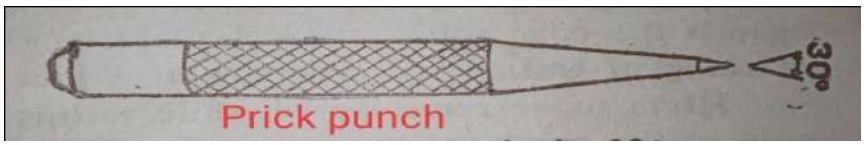
1] Dot punch is used for dotting. It's angle is 60 degree. Even after the lines are rubbed the punch mark should be there, till the job is finished.



2] Centre punch is ground at an angle of 90 degree. It provides a punch mark in which drills and other pointed tool will start easily. A deep mark is required for a drill to locate the exact place.



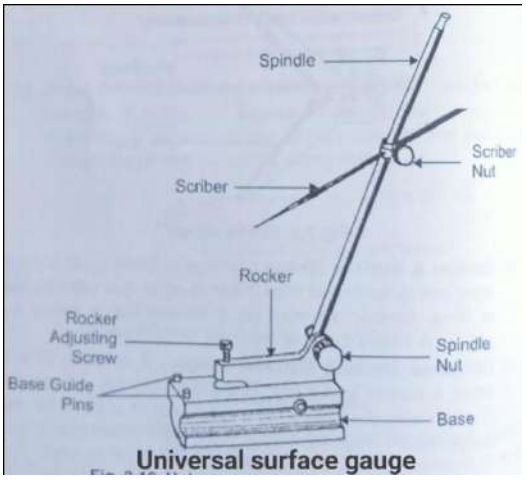
3] Prick punch gives sharp impression and long pointed life. It is generally used by blacksmiths as well as fitters while working on soft metals and for precision work. It's angle is 30 degree.



SURFACE GAUGE

Introduction:- It is an instrument having a base, a pillar and a scriber used for marking lines on surfaces.

Types: 1] Surface gauge ordinary. 2] Surface gauge universal.

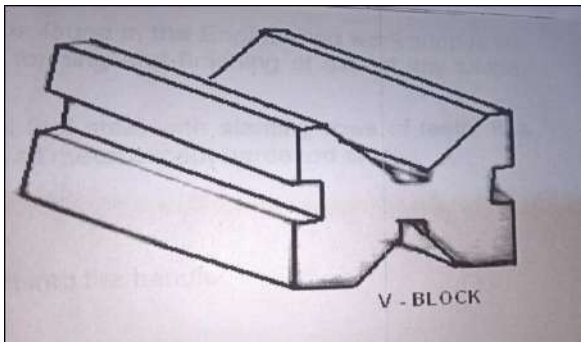


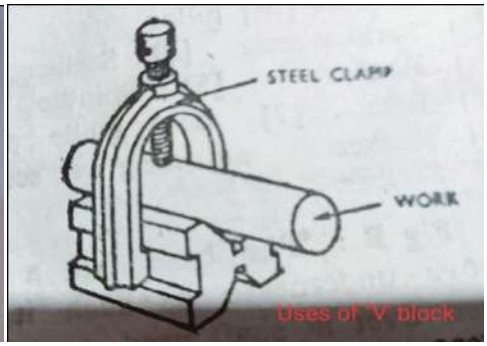
Hints to be remembered while setting:- 1] Prefer a steel rule. 2] Place an angle plate on the surface plate. 3] Rest the steel rule closely. 4] Raise the spindle of a surface gauge to vertical position and lock it. 5] Loose the scriber clamp and adjust the scriber point to an approximate height and

tighten it. 6] Adjust finally using the fine screw. 7] Draw line carefully.

‘V’ BLOCK

Introduction:- It is a rectangular or square block having V shaped grooves, as such it is called a ‘v’ block.





Materials:- It is made from closed grain cast iron, or cast steel. If it is made of mild steel it would be case hardened.

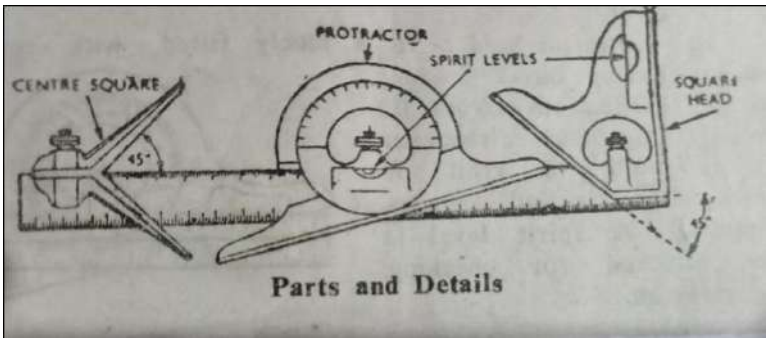
Uses:- ‘V’ blocks are used in single or pairs in layout work and to hold the circular stock firmly during marking, drilling, milling etc. The U-clamp has a screw on its top and it is used with the ‘v’ block for holding the rounds.

Classification:- It is classified by the length, breadth and height or thickness.

COMBINATION SET

Introduction:- It is an instrument consisting of four separate parts used for different nature of work, as such it is called a combination set.

Parts and details:-



1] Blade or rule:- It is made of high carbon steel or alloy steel hardened and tempered. It is graduated in Metric and English units having accurate machine

Divided lines. It has groove on one side throughout the length for holding the other three heads by means of a locking device. It is used for marking and checking of measurements, flatness etc.

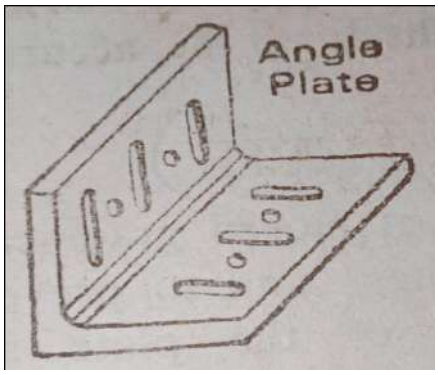
2] Square head:- It has one edge square that is 90 degree to the rule while the other edge forms 45 degree, using for marking and checking of angles.

3] Centre head:- It has two arms right angle to one another and exactly divided in to two by the top edge of the rule, if it is fixed in the rule. It is used to mark out the centre of round components.

4] Protector head:- It is nicely fitted with revolving turret having direct reading , double graduations from 0 to 180 degree on both directions. It is used to read or mark the inclined angles directly.

ANGLE PLATE

Description:- The angle plate is made from closed grain cast iron. All the two parallel faces are machined to a great degree of accuracy at right angles. It is used for marking purposes as well as checking the right angles.



Adjustable angle plate:- This type can be swiveled in both the direction, since the angle is marked up to 90 degree. Available size is 100 mm to 500 mm. This angle plate can be fixed in the marking table.

Available sizes:- These popular sizes are available and used commonly in the workshop are :-

1] 200 X 200 X 150 X 30 mm (8 inch X 8 inch X 6 inch X 1.5 inch)

2] 150 X150 X 100 X25 mm (6 inch X 6 inch X 4 inch X 1 inch)

MARKING OFF TABLE

Introduction:- A machine plate used for marking purposes is called marking of plate and if the marking plate is fixed on a metal stand that is called marking off table. The height may be fixed as 750 mm or 900 mm. from the shop floor.

Material:- The plate is made of cast iron and the stand is made of mild steel.

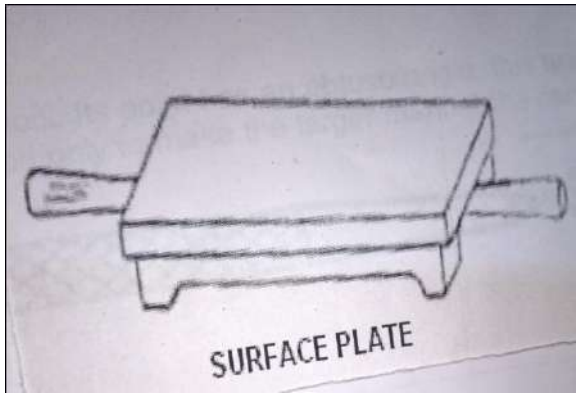
Uses:- It is used for placing the job and tools on it for marking purposes.

Popular sizes:- Though variety of sizes are available, one particular size is commonly used it is popular size. The popular size may be 75 cm X 75 cm X 60 mm or 3 foot X 3 foot X 2.5 inches.

SURFACE PLATE

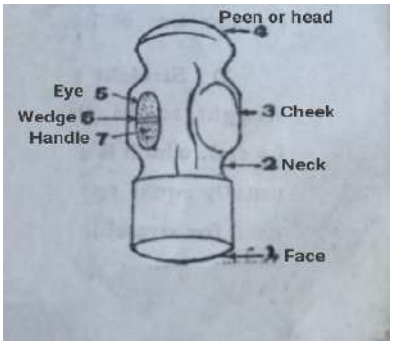
Definition:- The surface plate is made of closed grain cast iron, heavily ribbed underneath for strengthen and to prevent from distortion. The top side and ends of the plate are accurately machined.

Method of the testing a job on a surface plate:- When the filing and scraping work is over, rub the job on the surface plate applying a thin coating of marking media. Take the job away and note the spots. The transference marks are the high spots and are to be scrapped off. This operation should be repeated until the binding paints are showing over the entire surface uniformly.



HAMMERS

Introduction:- Hammer is a simple striking tool used to make the job to a required shape either in hot or in cold conditions beating directly on top of the job or tool.

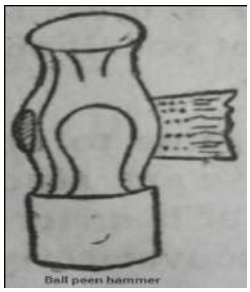


Material:- It is made of high carbon steel containing carbon 0.49 to 0.65%, Manganese 0.55 to 0.75%, Phosphorous maximum 0.06%, Sulphur maximum 0.6%, Silicon maximum 0.35%, as per I.S.I. standard.

Specification:-It is specified by the shape, weight, and I.S.I. number. (Eg) Double face sledge hammer 2.5 kg with handle.

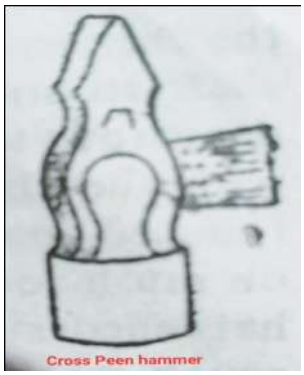
Types of hammer:- 1] Ball peen hammer. 2] Straight peen hammer. 3] Cross peen hammer. 4] Sledge hammer. 5] Claw hammer. 6] Soft hammer. 7] Mallet hammer etc.

1] Ball peen hammer:-The shape of the peen is like a ball. The convexity on the peen helps to spread the metal and is used for striking purpose and also it is convenient while riveting. The face side is used to give heavy blow.



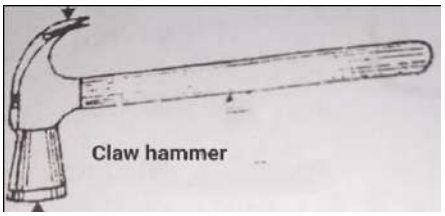
2] Straight peen hammer:-The peen is straight to the shaft and is tapered flat towards its end, which is curved and rounded.

3] Cross peen hammer:-The peen is similar to the straight peen hammer but the peen is across the shaft or eye hole. It is used for striking in to shoulders or inside curves for bending and for stretching the metal.



4] Sledge hammer:-The head of this hammer has two identical cylindrical faces at both ends. It is heavy type hammer varying in weight from 6 to 15 pounds. It is more useful to blacksmiths for heavy striking on hot condition.

5] Claw hammer:-It is more useful for carpenters. Its head is splited conveniently used as a nail puller.



6] Soft hammer:-These hammers are made from soft material such as lead, copper etc. and so it is called soft hammer. It is used for striking on finished or polished surface to protect the job from fracturing.

7] Mallet hammer: It is made of hard wood and it is more useful for carpenters and sheet meal workers, used to form even surface or bending the metal sheet.

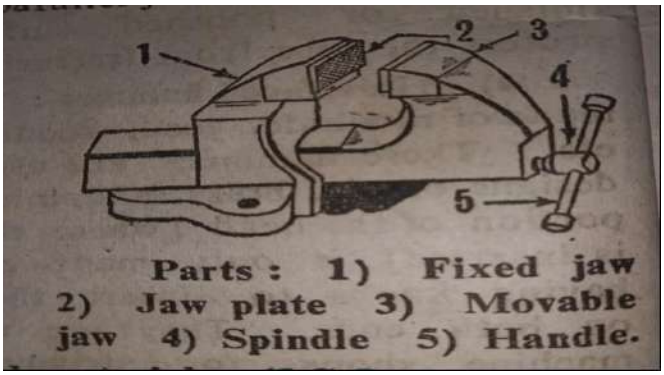
VICES

Introduction:-A device used to holds the job firmly is called vice.

Types of vices:- 1] Bench vice (Parallel jaw bench vice, Fitter's vice). 2] Hand vice. 3] Leg vice. 4] Pipe vice. 5] Pin vice. 6] Tool makers vice. 7] Machine vice. Etc.

1] Bench vice:-The device used to hold the job firmly fixed on a bench is called bench vice.

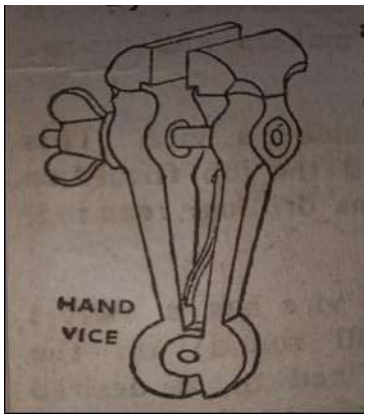
The vice has a movable jaw, a fixed jaw, a screw rod, a boxnut, two serrated jaw pieces are fixed with countersink screws in the face of both jaws to

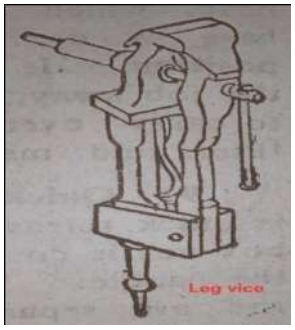


hold the job firmly. The movable jaw is always moving parallel to the fixed jaw and so it is called parallel jaw bench vice. The spindle has square threads(right hand) with suitable nut and it acts the movable jaw by the handle. The movable jaw is nearing towards the fixed jaw if the handle is rotated on clockwise till the job is held firmly. The handle may be turned in anticlockwise to release the job.

Classification:-It is classified according to the width of the jaws, i.e. 100 mm, 125 mm, etc. [E.g.] Parallel jaw bench vice 100 mm [I.S.I.]

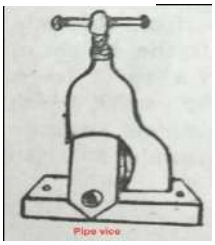
2] Hand vice:-It consist of two jaws and a bolt fitted by a hinge system to operate the jaws. It is classified by the breadth of the jaws. The vice is used to hold the small jobs such as screws, keys, pins etc. The vice is held by the user's left hand to carry over the minor operations.

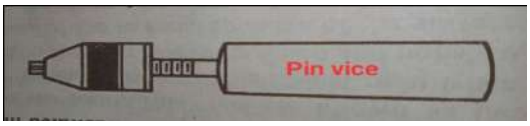




3] Leg vice:-The leg vice has two jaws, one is fixed with a leg to stand on the earth in-front of the bench and clamped. It is used for heavy duty works in blacksmithy section. It is classified by the breadth of the jaws.

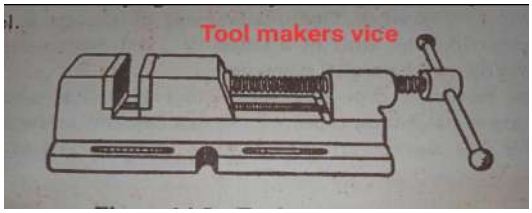
4] Pipe vice:- It is consist of a body, jaw, and handle. The mouth of the jaws are in V. shape .The bottom jaw is moulded with the body. The movable jaw is acting up and down by a screw. It is classified by the maximum diameter of a pipe which enter between the jaw.





5] Pin vice:- It holds minute job as pins, needles etc. It is used by watch repairers also. It is made from steel. It is classified according to the maximum diameter that can be held in the vice.

6] Tool makers vice:- It is made of steel. It is convenient to hold small jobs by tilting the vice according to the operation to be carried out. It is more useful for tool makers and instrument mechanics.

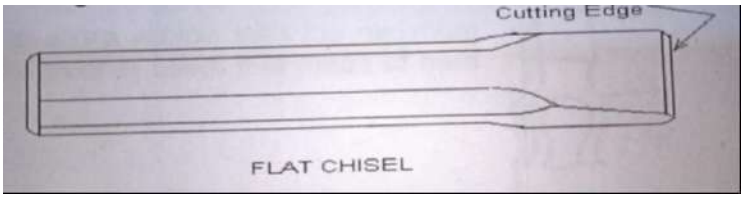


7] Machine vice:- It is similar to tool maker's vice. This type of vice is fitted on the machines to hold the job firmly to carry out the machining operation such as drilling, shaping etc.

CHISEL

Definition:- A chisel is a cutting tool made of high carbon steel of hexagonal or octagonal bars. It is classified according to the length, width of face and the shape of cutting point. The cutting operation with a chisel is called chipping.

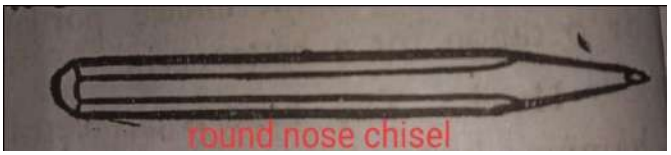
Type of chisel:- 1] Flat chisel. 2] Cross cut chisel. 3] Half round or round nose chisel. 4] Diamond point chisel.



1] Flat chisel:- It has a slight curve on the face. It is used for chipping large surface and general cutting purposes. Burrs, sharp edges, and high metal spot in casting parts are chipped off with a flat chisel. The required length is 150 mm or 200 mm.

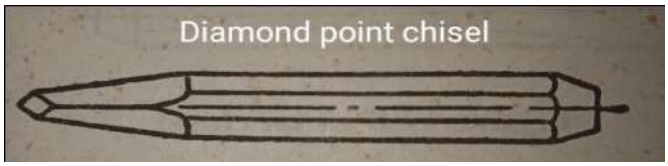
2] Cross cut chisel or cape chisel:- It is used for cutting keys way and slots.

The key ways are cut over the shafts, spindles and in the bore of pulleys, fly wheels, gears etc. The cutting face is wider than back, because to enter the body freely into the cut path of the key way.



3] Round nose chisel:- It is used for cutting of oil grooves in the bearings, pulleys, and bushes. It is also used for chipping to draw back the centre of the drill point correctly, when it goes out of centre while drilling.

4] Diamond point chisel:- The shape of the cutting point Is diamond used for chipping the 'V' shaped oil grooves and also making the sharp corner in square or angular holes.

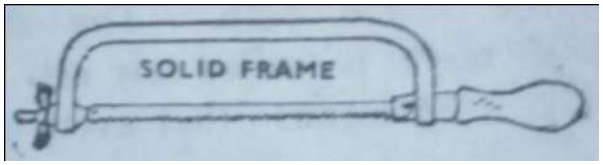


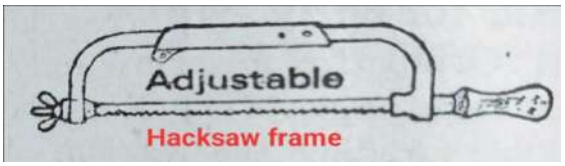
HACKSAW

Introduction:- Hacksaw is a tool consisting of a frame and a blade. It is used for cutting the surplus metal on the scribed line. The operation is called Hacksawing.

Description of frame:-

1**] fixed frame:-** It is more rigid and used to hold a particular size of blade.





2] Adjustable frame:- It is used to hold the hacksaw blade of different lengths. The frame is made of two pieces and easy for adjustment to hold a desired length of blade.

Materials:- The frame is made is made from mild steel, case hardened except the handle which is made of wood.

HACKSAW BLADE

Introduction:- Hacksaw blade is a cutting tool fitted in a frame to a correct tension and may be tested from sound by giving blows with a finger on it after tightening.

Materials:- It is made of high carbon steel, High speed steel, alloy steel hardened and tempered.

Classification:- It is classified by the length of the blade measuring the distance between the centre of the two pin hole and the spacing (pitch) of the teeth.

Types of hacksaw blade:-

1] The flexible blade:- It is made from high carbon steel. The teeth along are hardened and tempered leaving the body soft and tough to resist the vibration.

2] All harden blade:- The body and teeth are hardened and tempered to give more strength, since its thickness and width are lesser than a flexible blade. Though it is called all hardened blade the both ends into the pin hole having no temper to avoid any breakage.

FILES

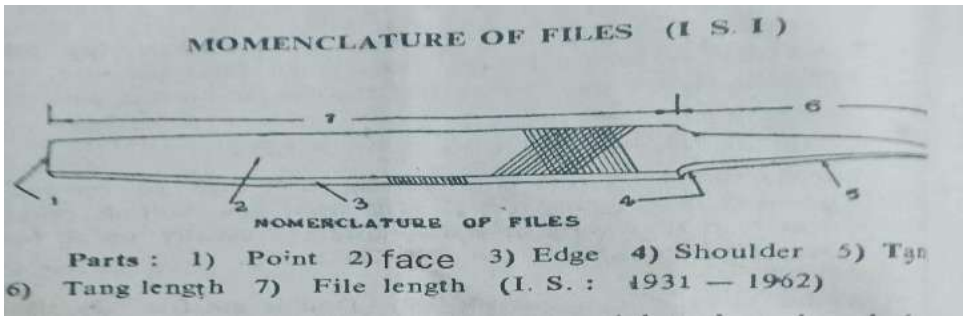
Introduction:- A file is a cutting tool used to remove a small quantity of surplus metal. The file have cutting points incorporated in the body at equal distances usually on all faces over the length from the shoulder to tip.

Parts :- 1] Point 2] Face 3] Edge 4] Heel 5] Shoulder 6] Tang.

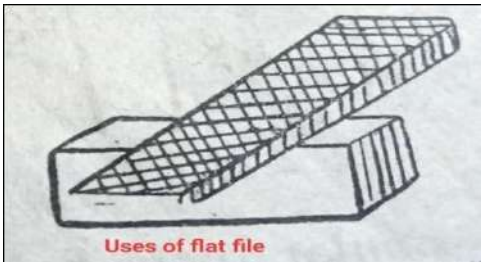
Materials:- Files are made from special tool steel and they are hardened and tempered, having the tang part soft and tough to prevent from easy breakage.

Classification of file:- Files are classified according to their section, length, cut and grade.

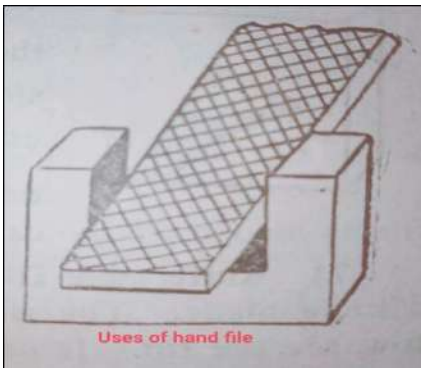
Files section and their uses:-



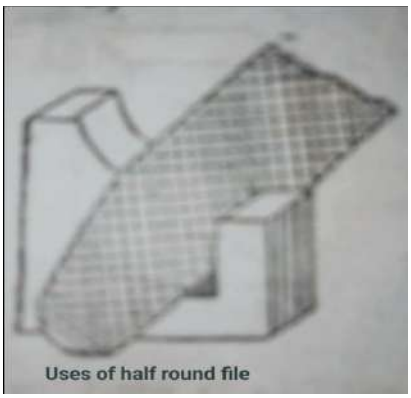
1] Flat file:- It is rectangular in section parallel for about two third of its length and then tapering towards the point in width and thickness for easy engagement. It is available from 150 mm to 400 mm long. It is the most useful file to do all general purposes of filing on flat surfaces.

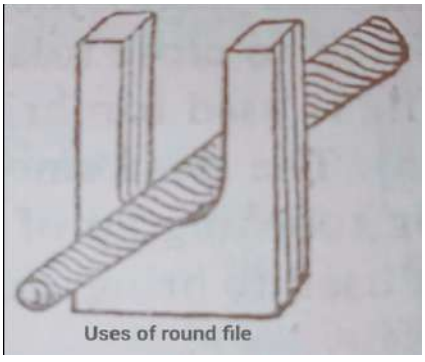


2] Hand file:- It is rectangular in shape and parallel in width. It has a blank edge has no teeth) since on filing the blank edge does not spoil the adjacent side and so it is called safe edge file. It is used for filing steps, shoulders to square work but not touching or spoiling the adjacent side which was already made true.

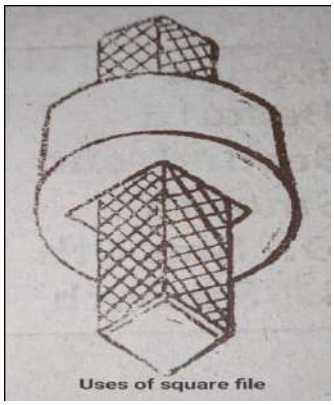


3] Half round file:- It is segmental in section and has double cuts on its flat faces and single cut on the curved surface. It is used for enlarging the holes, bores, as well as filing on the concave and convex surfaces.



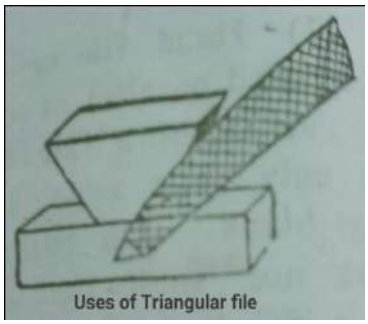


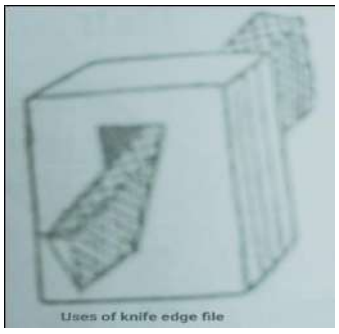
4] Round file:- It is circular in section having the same diameter up to two third of its length and then taper towards the tip. It is used for enlarging the round holes as well as making round corners and curves.



5] Square file:- It is square in section. It is used for filing the square holes and bottoms of key ways, channels grooves, slots, gear teeth etc.

6] Triangular file:- The section of the file is triangular at an angle of 90 degree. It is used for filing on 'v' grooves and clear the corners. The file is also used by carpenters for sharpening the hand saws.





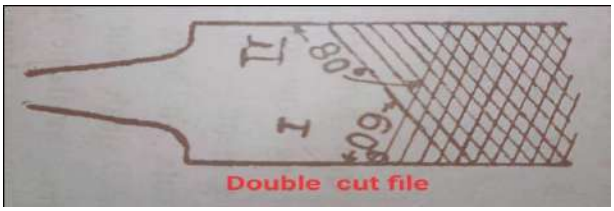
7] Knife edge file:- The width of the file is tapered like a knife blade. It is used for filing jobs of acute angles and also to finish the sharp corners of grooves, slots etc. perfectly.

Cut of file:-

1] Single cut file:- The cutting points are arranged in single rows either straight

or curved and so it is called single cut file. The inclined angle is 60 degree to centre line. It is used for filing on soft metal such as brass, copper, lead, aluminium etc. and non metals. It is also used for fine finishing and some times for draw filing.

2] Double cut file:- These files have two set of teeth cutting diagonally each



other. The first cut is cut at 50 degree to 60 degree angle and the second cut or up cut is cut at an angle of 75 to 80 degree. It is used for all the general purposes of filing.

3] Rasp cut file:- The rasp cut file is similar to a half round tapered file. It has course and fine triangular shaped teeth projecting over the body. It is used for filing on woods, ivory, bone, horn etc. It is more useful for carpenters.

Grade of cut in file:- It indicates the fineness cut determining the number of cuts of a file on 1 cm or 10 mm length resulting from spacing of teeth. In ascending order of smoothness they are listed as 1] Rough 2] Bastard 3] Second cut 4] Smooth 5] Dead smooth and 6] Super smooth.

A table will gives you a fair idea

Grade	Number of cuts over a length of 10 mm							
	Length of file in mm							
	100	150	200	250	300	350	400	450
Rough	10	8	7.1	6.3	5.5	5.3	4.8	4.5
Bastard	18	13	11	10	9	8	7	6
Second cut	21	17	16	15	14	13	12	11
Smooth	30	24	22	20	19	18	16	15
Dead smooth	35	33	31	30	28	_	_	_
Super smooth	63	49	45	40	_	_	_	_

Various points on file

1] Convexity of file:- The file have a slight convexity in lengthwise instead of straight, so that they reduce the friction with the job and easy for filing. The convexity gives the better distribution of the pressure and makes up for slight, but inevitable differences of the filing movement. In order to facilitate filing of

even surfaces, many files are gradually narrowed i.e. convexed. When filing on a surface, all the teeth contact closely if the surface of the file is straight, and it would be very difficult to control the file.

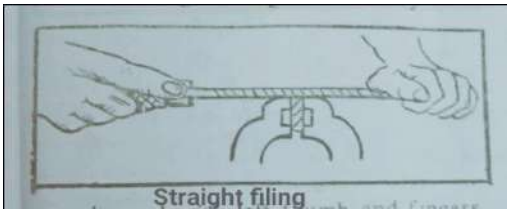
2] Stroke of file:- The teeth are cut from heel to tip. The file is pushed over the job i.e. cutting stroke and pulled back i.e. return stroke. The every two actions are called stroke of file.

3] Selection of file:- The file may be selected according to the nature of work, material, shape and size and the surface quality. The rough and bastard file may be used for rapid reduction and second cut and smooth file for finishing the job. The dead smooth file may be used for fine finishing. The file should be 150 mm long more than the length of the to be filed.

Filing operations

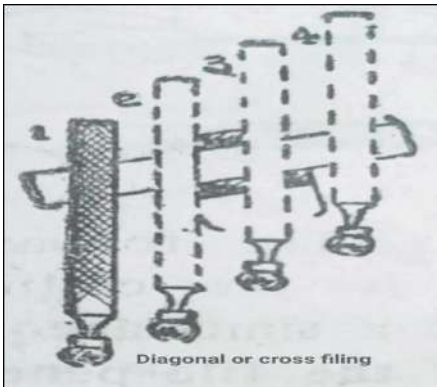
Filing is an operation of removing small chips of the job with a file. The file moves back and forth. The forward movement is the cutting motion and a simultaneous pressing of the file penetrates in to the metal and removes small chips. The return movement is effected without pressure.

1] Straight filing:- Pushing the file as straight as possible is called straight filing.

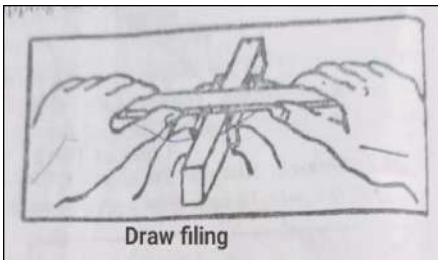

Straight filing

For heavy reduction hold the opposite end of the file with the left hand and press with palm on cutting stroke only. On light work it is enough to hold the opposite end with left thumb and fingers. Apply even pressure always.

2] Diagonal or cross filing:- The tip of the file is placed on the job and it moves diagonally over the job. At the finishing of stroke the file (heel side) is on the other end of the job. This is called diagonal or cross filing. The file starts the cut from the point and it comes to the close up to heel at the end of each stroke.



3] Draw filing:- The file is hold parallel to the shoulder or across the job, gripping on both end by hands for pushing and pulling over the job is called draw filing. It is used on the final stage to remove the spot and to the best finishing of the job. The single cut file may also be used for draw filing.

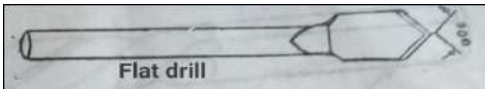


DRILLS

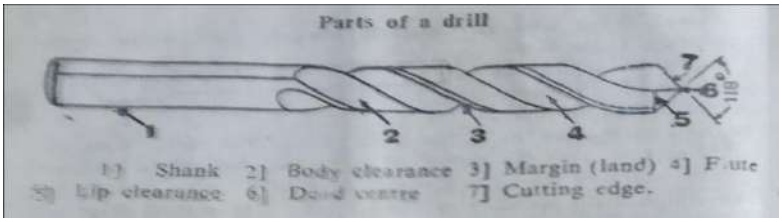
Introduction:- A drill is a cutting tool used to make round hole. In olden days the drilling operation was done by using flat drill. The flat drill have lost its position, since they are not fit for nowadays.

Types of drill

1] Flat drill:- The drills are forged by blacksmiths. It is made of high carbon steel and the cutting edge is shaped as flat according to required size. It has cylindrical shank and is flattened towards the cutting edge. The cutting angle is 90 degree.



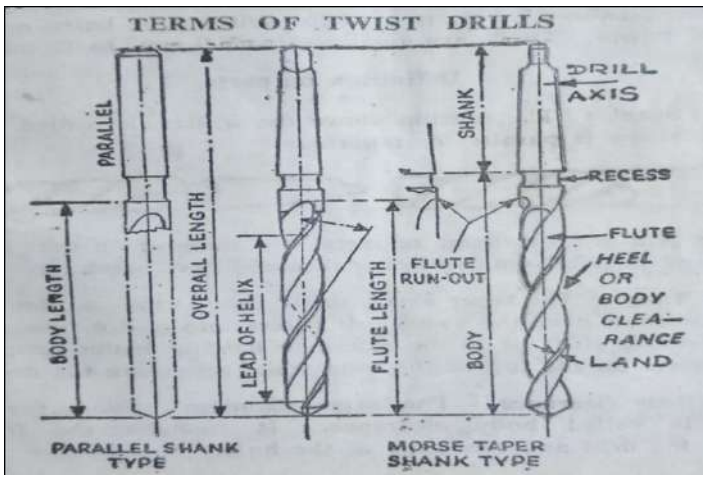
2] Twist drill:- The shape of shank is different but the body is common for all the types of twist drill. The cylindrical body has two helical grooves running over its length and a conical point



on the cutting edge. The formation of the flutes are twisted and so it is called twist drill. It is available in all standard sizes in Metric and English units.

Materials:- The twist drills are made of high carbon steel and high speed steel. The size of the drill is also stamped.

Classification:- The twist drill are classified according to the shape of the shank and the size of the body.



Types and uses

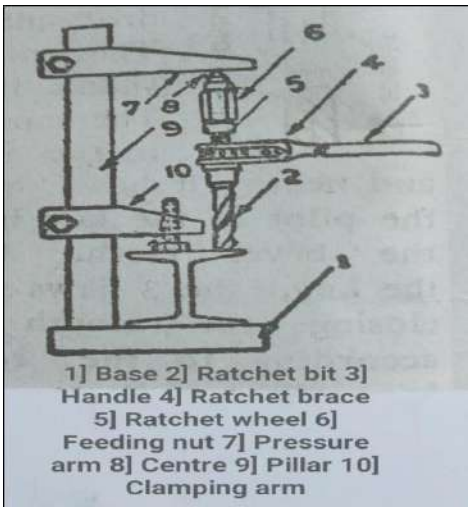
1] Straight shank drill or parallel shank drill:- It is used for accurate drilling in sensitive drilling machine. It requires a drill chuck. A key is used for tightening and loosening the drills.

2] Taper shank drill:- The taper shank drill is inserted in the feeding shaft directly or into the mores taper sleeve. It is used for drilling large size of holes also. A drift is required to remove the drill from the shaft or the sleeve.

DRILLING

Drilling is an operation using a drill and drilling machine. The drill is to be rotated in a stationary job having feeding mechanism and the machine may be operated by muscular (hand drilling) or electric power (power drilling).

DRILLING (HAND PROCESS)



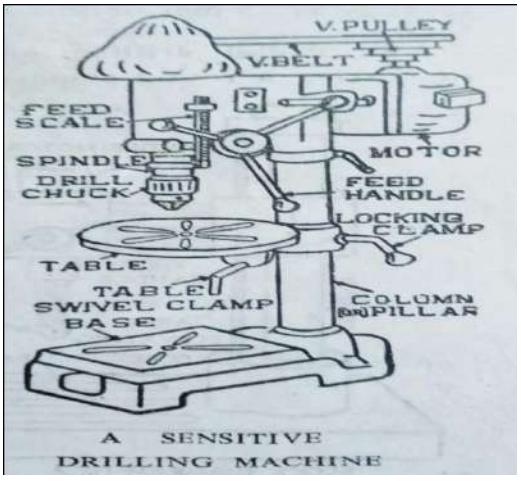
1] Ratchet:- It is a portable hand drilling machine. It consist of a pillar post, Supported arm, and a ratchet brace. It is used for drilling on heavy weight jobs, irregular shaped jobs and also where electricity is not available.

2] Hand drilling machine:- It consist of a handle, two bevel gears, a body, a spindle and a chuck. The mechanism is too simple.

3] Breast drilling machine:- It is similar to a hand drilling machine but having a breast plate on the top instead of a handle. It can be used either vertically or horizontally pressing the plate by breast and so it is called a breast drilling machine.

POWER DRILLING MACHINE

A drilling machine has a spindle and it holds a drill bit. It rotates with the spindle in various speed having feeding mechanism and such machine tool is called a power drilling machine.

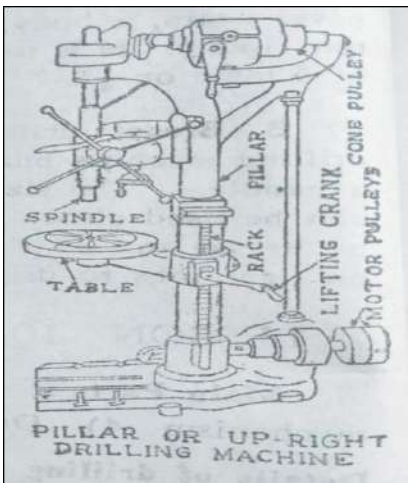


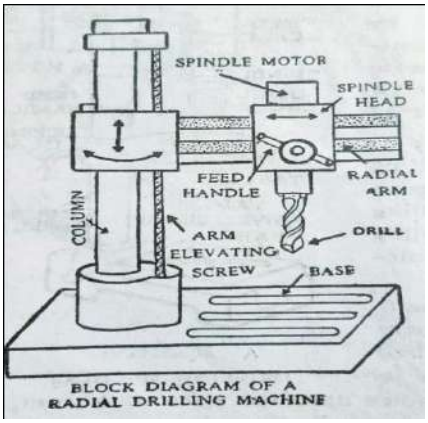
1] Sensitive drilling machine:- It is used for drilling hole accurately. The feed is given by a lever which enables the cut by feeling and so it is called a sensitive drilling machine. It is more useful to fitters and tool makers to drill up to the size of 12 mm or half inch.

2] Bench drilling machine:- A small pillar type vertical drilling machine is fixed on the work bench an so it is called a bench drilling machine. It is light duty drilling machine used for drilling the hole upto 12 mm or half inch.

3] Portable drilling machine:- It is more convenient to drill small holes upto 12 mm or Half inch. The feed is given by the operator's muscular power. It has a long cable having three point plug pins. The switch is so designed to control it by the user's hand, while working and also there is a locking arrangement for constant running.

4] Pillar type drilling machine or Upright drilling machine:- A drilling machine with motor is fixed on the top of the pillar and it is possible to fix the machine on the pillar at any place. A movable table is also fixed in the pillar under the machine. The feed can be given either by automatic or hand. The required speed can be obtained by cone pulley or gear system.





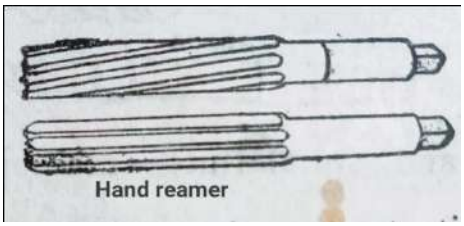
5] Radial drilling machine:- It consist of heavy base supporting a round column at one end. An arm is fitted on the round column and it moves up and down. The arm can be swiveled to drill anywhere on the table or out of the table. A radial arm swivels to form a circular movement and so it is called radial drilling machine.

REAMERS

Introduction:- A reamer is a side cutting tool and used into a drilled hole for enlarging the size from 0`07 mm to 0`3 mm. to have accurate size as well as smoother finish. The process is called reaming.

Types of reamers

1] The hand reamer:- it consist of a head, shank and body. The body has spiral or straight cut flutes which are cut by machines making the edges sharp. It is made from tool steel, hardened and tempered. The reamer has a number of cutting edges contacting through the hole, to give a better and smooth finishing.

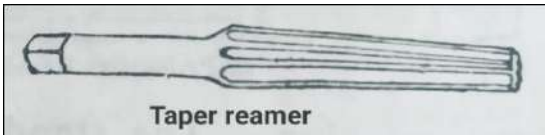

Hand reamer

2] The machine reamer:- It has a taper shank to grip firmly into the machine spindle like a taper shank drill. The cutting edges are similar to all the reamers. The speed may be selected to half of the R.P.M. to the same size of a drill.

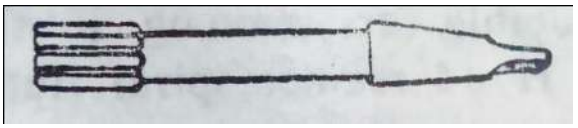
Kinds of reamers

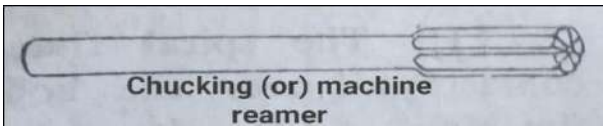
1] Parallel reamer:- It has even size throughout the reaming portion (body) and the flutes are in spiral or straight cut.

2] Taper reamer:- It is tapered from half of its length towards the tail and the flutes are straight. The taper portion enters into the hole giving rigidity and easy to work making the hole to a standard taper.

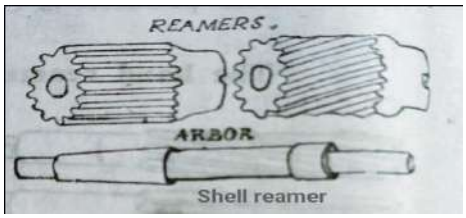

Taper reamer

3] Chucking (or) machine reamer:- There are two types 1] Straight shank rose reamer 2] Taper shank fluted reamer.



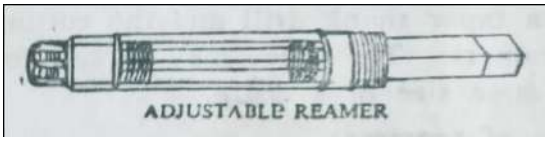

Chucking (or) machine reamer

4] Shell reamer:- It is a hollow round piece having standard holes, to suit in an arbor. The arbor has a mores taper shank and permits the various sizes of shells into its body with a locking device.



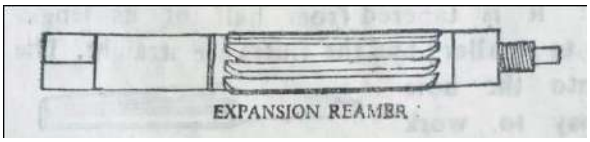
Shell reamer

5] Adjustable reamer:- Five or six cutting blades slides on a tapered



Longitudinal slots made over the round of the body. They are positioned by locking two nuts, shifting the blade upward and downward for adjusting to a desired size.

6] Expansion reamer:- In this reamer the expansion form is split up through



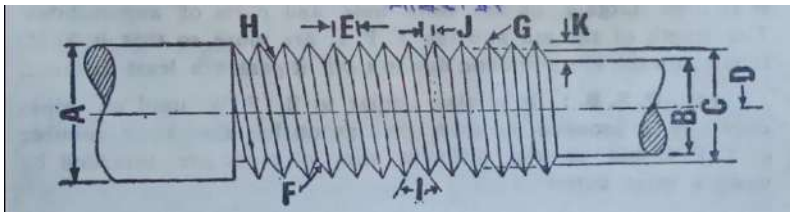
fluted section by screwing in a tapering plug. Helical fluted expansion reamers are also available.

THREADS

Introduction:- The thread is a projecting ridge of uniform shape throughout its length, wrapped on the internal and external surface of a cylinder is a regular spiral or helical fashion, example for external threads are screws, bolts, studs. Example for internal thread is nut. According to the direction of rotation of thread it may be termed as clockwise (right hand) or anti clockwise (left hand) threads.

Uses:- 1] To work as a fastener. 2] To transmit the motion. 3] To make adjustment. 4] To resist the load. 5] To have accurate reading. 6] For quick setting. 7]Easy to separate.

Terminology of threads



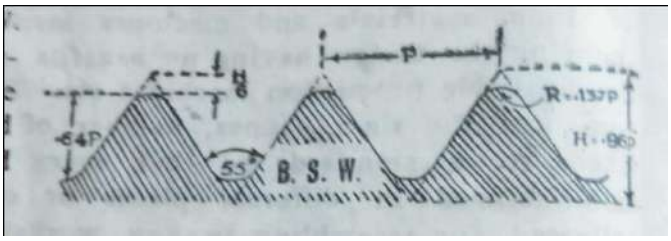
A] Major dia. B] Minor dia. C] Pitch dia. D] Axis of screw E] Pitch F] Flank or side G] Crest H] Root I] Angle of thread J] Helix angle K] Depth L] Lead.

Types of threads

1] V. Threads:- The threads which are formed in “V” shape are called V. Threads.

Various V. Treads

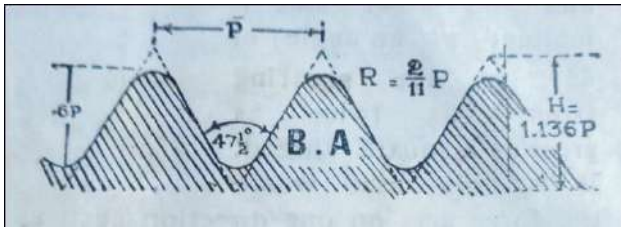
A] B.S.W. :- This is the first standardized thread and the angle is 55 degree. It is used in common nuts and bolts, screws etc.

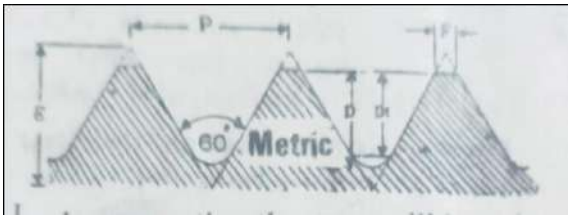


B] B.S.F. :- It is similar to B.S.W. having fine pitches. It is used on the bolts, nuts and parts of automobile.

C] B.S.P. :- It is also similar to B.S.W. used on pipes only.

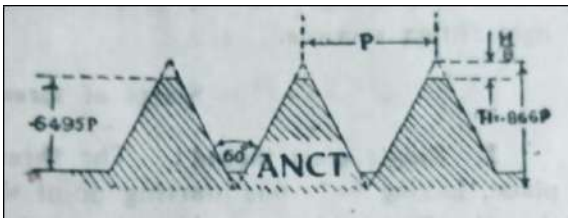
D] B.A. :- The included angle of British association is 47 ½ degree. It is used for making screws below ¼ inch dia.

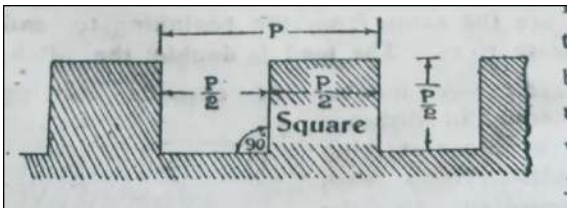




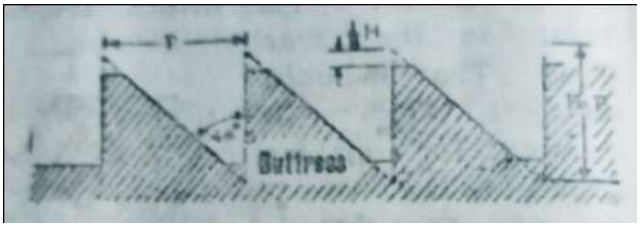
E] Metric:- The angle of metric threads are 60degree. It is used on all general purposes.

F] American National Thread:- The angle is 60degree. The threads are used in the place of English system.



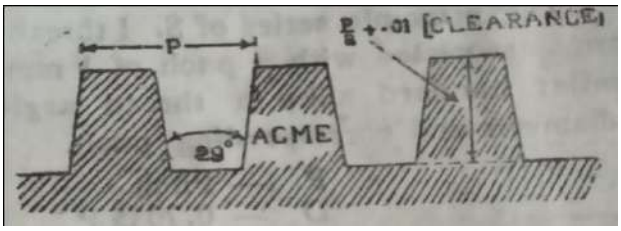


2] Square thread:- Its shape is square at an angle of 90degree. It is strong enough to transmit heavy loads on both directions. It is used on the spindle of vices, screw jack etc.

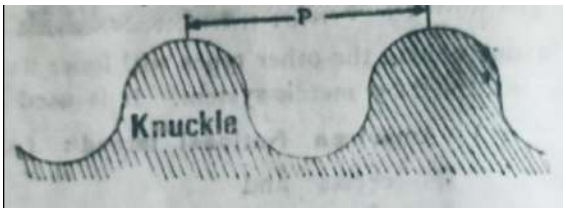


3] Buttress thread:- It has one surface normal to the axis and and the other side is 45degree. It is only used where the force acts on one direction such as quick release vice, hand press etc.

4] Acme threads:- The acme thread has the same depth similar to a square thread but its included angle is 29degree.



It is used in automatic working machine.



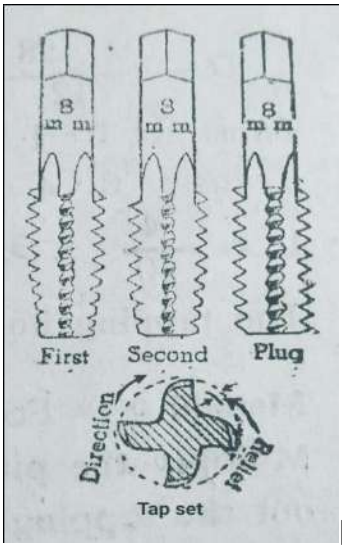
5] Knuckle thread:- The shape is half round on the crest. It is used for rough usages, in the parts of coupling etc. It is also used for light fitting services.

TAPS

Introduction:- A tap is an internal thread cutting tool hardened and tempered. It has a square head on the top, and having grooves running lengthwise intersecting the threads to form cutting edge.

Set of taps:- The tap set consist of three taps. The name of three taps are :-

1] First tap or Taper tap:- The first tap has taper sides and the threads are flattened over one third of its length from the beginning for inserting easily into the drilled hole.



2] Second tap or Intermediate tap or Medium tap:- The second tap has light taper and the threads are flattened over one sixth of its length and it forms better threads which is left incomplete by the first tap.

3] Third tap or Finishing tap or Plug tap or Bottoming tap:-It has straight sides having full of threads from its bottom. It is used on final stage, to clean all burrs to make full shape of threads.

Tapping

Tapping is an operation making internal threads into the holes by means of tap.

Tapping hole:- It is a plain hole drilled for a particular size of a tap. If the size of the hole is larger, the threads will not form in full shape. If the size of the hole is smaller, it will be a cause to break the tap.

Formulae for tapping hole:- (In English unit) 1] $H = D - 1.28/N$

2] $H = D - (P \times 1.28)$

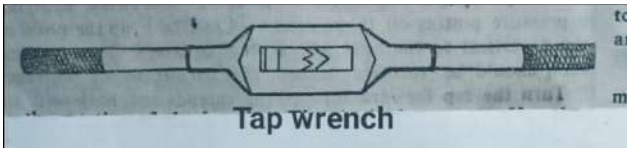
Here,:- H = Hole, D = Dia. of the tap, N = Number of T.P.I. P = Pitch.

(In Metric unit) 1] $H = T - 2dp$

2] $H = T \times 0.8$

Here,:- H = Hole, T = Tap size, d = depth of thread, p = pitch.

Tap wrench



Tap wrench is a device used for holding the square head of a tap firmly while tapping. There are two types 1] Solid type and 2] Adjustable type.

DIES

Introduction:- It is an external thread cutting tool. There are cylindrical or square flutes Intersecting threads to form cutting edge. It is made of tool steel hardened and tempered. Cutting external thread on a round rod with a die and die stock is called **Dieing.**

Types of dies:- There are mainly two types of dies in common use:- 1] Solid die, and 2] Adjustable die.

1] Solid die:- The shape of the die may be square, hexagon, and circular. It cannot be adjusted for larger or smaller diameter.

2] Adjustable die:- Adjustable means that it can be set to cut larger or smaller diameter. A circular adjustable split die is very common. The die is split through one side and a slight adjustment is made by means of the set screw. Another common type is the two-piece rectangular die. In this type the dies are fitted into a special stock and they are closed by means of the adjusting screw.

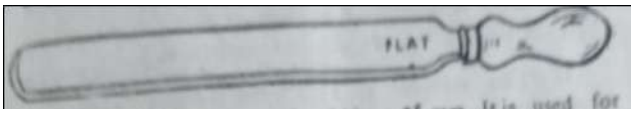
DIE STOCK

Introduction:- It is a tool used for holding the die pieces while cutting external threads. It is available in two shapes i.e. Solid and Adjustable type.

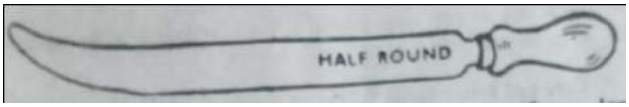
SCRAPERS

Introduction:- A scraper is a cutting tool used to remove the high spot by hand process for obtaining a high degree of accuracy. The operation is called scraping. The scraper is similar to a file having a handle but it has no cuts. All the sides are ground and they have sharp cutting edges.

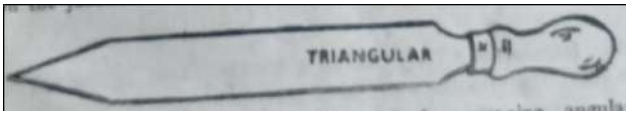
Types



1] Flat scraper:- The section of the scraper is flat. It is used for scraping flat surface.



2] Half round scraper or bearing scraper:-Its shapes is half round and it is bent towards the end. It is used for scraping in bearing, bushes and concave surfaces.



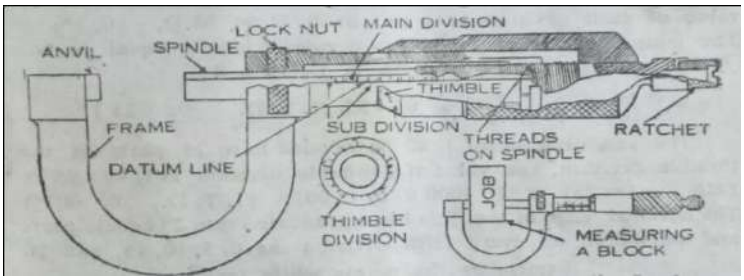
3] Triangular scraper:- It has three sharp cutting edges in the junction of the three faces and taper towards the end. It is used for scraping angular surfaces to make sharp corners.

Precision Measuring Instruments

MICROMETER (EXTERNAL)

Introduction:- The word micrometer is derived from two Greek words. Micro means small or little, and meter means, a measure. It is easily understood that the word micrometer means. It is an instrument used for gauging small or fine measurements. The other name is **Screw gauge** since it work under the principle of a screw.

Construction:- It is composed of a frame, like the shape of letter U. At one end of the frame there is a contact face called an anvil. A moving spindle with a screw adjustment is fixed at the other end. On the outer of the spindle a sleeve is rigidly attached which encloses the spindle. The sleeve telescopes into the thimble attached to the outer end of the spindle. A ratchet stop is fixed at the far end. A knurled locking nut is fixed around the spindle.



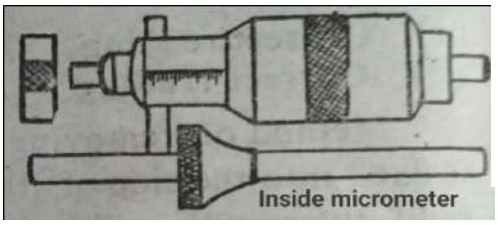
Main parts:- 1] Frame 2] Anvil 3] Spindle 4] Lock nut 5] Sleeve 6] Thimble 7] Ratchet stop.

Uses:- It is used for measuring the outside dimensions of round or flat jobs to an accuracy of 0.01 mm or 0.001 inch.

MICROMETER (INTERNAL)

Introduction:- A micrometer which is used to measure the inner dimension accurately that is called inside micrometer. It shows a great accuracy of 0.001 inch or 0.01 mm. which cannot be measured with a rue or a caliper.

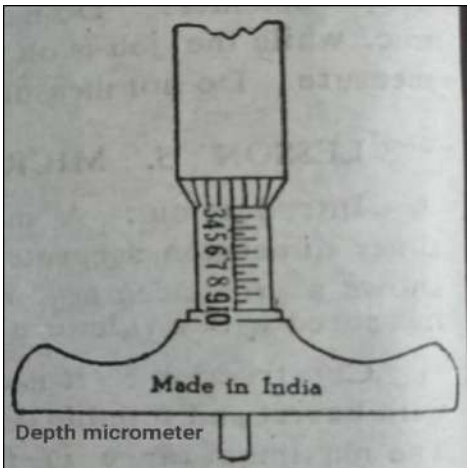
Construction:- It is composed of a head having measurements with barrel and Thimble divisions like outside micrometer. The maximum range in English is ½ inch and Metric is 10 mm. They have a set screw arrangement to fix the extension rods.



A knurled handle is inserted on the outer portion of the head to hold the micrometer conveniently when it is on use.

Uses:- It is used for taking minute measurement of inner dimensions in the hole, bores, slots, etc.

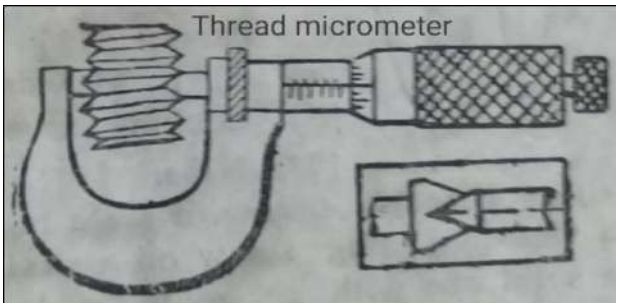
DEPTH MICROMETER



Introduction:- It is a precision instrument used to measure the depth of holes, bores, slots, pockets, grooves etc. It consist of measuring rods, a base, barrel and thimble like outside micrometer, but it has no frame and anvil.

THREAD MICROMETER

Introduction:- The thread micrometer is an instrument for checking the pitch dia. of threaded rod.

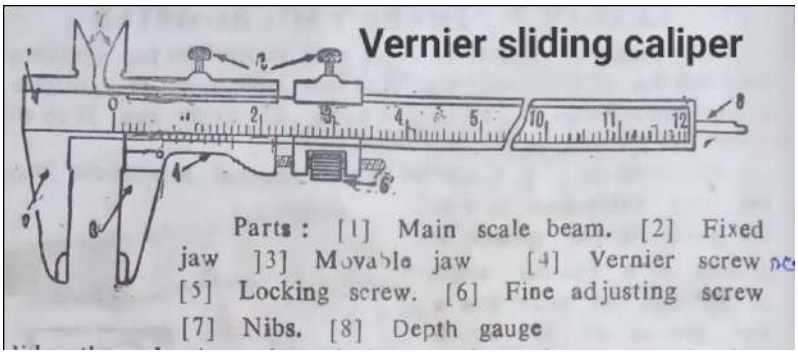


Construction:- It is similar to an external micrometer but the only difference is that the point of the spindle is ground to a conical angle of 55 degree and the anvil has a "V" groove of 55 degree which is suitable to the threads angle.

Uses:- It is used for checking the pitch diameter of screw threads having V shaped threads at an angle of 55 degree. Separate micrometer is also available to measure the threads which has 60 degree angle.

VERNIER SLIDING CALIPER

Definition:- It consist of a main scale, dividing with any numbers of graduation and taking some of the parts from the main scale, the vernier scale is prepared.


Vernier sliding caliper
Parts : [1] Main scale beam. [2] Fixed jaw [3] Movable jaw [4] Vernier screw
[5] Locking screw. [6] Fine adjusting screw
[7] Nibs. [8] Depth gauge

The movable jaw slides through the main scale beam and can be accurate with a fine adjusting screw on a desired position. The fix jaw is a solid one with the main scale. On the other end of the two jaws, some types have nibs for measuring the inner dimensions. Some calipers have a groove along the length of the beam and a narrow blade slides with the movable jaw and it is used to measure the depths of the hole, bore, slots etc.

Uses:- It is used to measure the outer dimension of rounds flats, square components and also the inner sizes of the hole and bores. A narrow blade is used to measure the depths of bore, slots etc.